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Prepared by participants in the 1968 National Defense Education Act Institute on Wood Technology, this syllabus is one of a series of basic outlines designed to aid college level industrial arts instructors in improving and broadening the scope and content of their programs. The primary objective of this course outline is to point out the importance and the many uses of wood and wood products. Topics covered are: (1) Lumber Grades and Sizes, (2) Plywood, (3) Veneer, (4) Fiberboard, (5) Particleboard, (6) Sheetboard, (7) Insulation Board, (8) Structural Sandwich Construction, (9) Shingles, (10) Pulp and Paper, (11) Wood Flour, and (12) Cellulose-Derived Products. Most units contain information on manufacturing processes, properties, types and grades, and uses of the products. Selected bibliographies are listed for each unit. The final section provides instructional aids, suggested projects and student activities, and materials and equipment needed for specific projects. The document is illustrated with drawings, charts, and photographs. Related documents are available as VT 007 857, VT 007 858, and VT 007 861. (AW)

LUMBER & RELATED PRODUCTS

A
BASE SYLLABUS
ON
WOOD TECHNOLOGY

Prepared by
INSTITUTE PARTICIPANTS

N.D.E.A. INSTITUTE
for advanced study in
INDUSTRIAL ARTS
June 10 - August 2, 1968

LUMBER AND RELATED PRODUCTS

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in the

Wood Technology

N.D.E.A. Institute

EASTERN KENTUCKY UNIVERSITY

June 10-August 2, 1968

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PREFACE

Recently, the area of woodworking has come under much criticism as being too limited in scope and not fully abreast of an advancing technology. Some people have gone as far as to seek its abolition from the industrial arts program in the secondary schools. In reality, however, the importance of woodworking as a phase of industrial arts is probably greater now than ever before. It is conceded, nevertheless, that the scope and content of industrial arts woodworking programs needs to be improved.

Traditionally, a typical woods program is centered upon the use of hand and machine tools with little or no emphasis given to the problem of familiarizing students with technical knowledge of the material itself.

To assist in the upgrading of present programs, students and teachers should, in addition to the use of wood as lumber, be made aware of the various properties of wood and wood products. Of equal importance is a knowledge of new processes and materials used in conjunction with the fabrication, manufacture, and application of wood and wood-related products.

The purpose of the NDEA Institute in Wood Technology held at Eastern Kentucky University during the period June 10 - August 2, 1968, was to provide college level industrial arts woodworking instructors with the opportunity to receive information in depth which they might use to broaden the scope and content of their programs. To this end, the participants have prepared this series of Basic Outlines which attempt to record their experiences during the period of the institute. The "Base Syllabus" prepared by the participants in the 1967 Wood Technology institute was used as a guide in developing the format of this series.

It is hoped that the material covered herein will be applied to the improvement of each participant's woodworking program and lead their students to a greater understanding of wood and wood products.

Jack A. Luy

Institute Director

LUMBER AND RELATED PRODUCTS

Introduction

Wood is one of our nation's greatest resources. It has been harvested and manufactured into countless forms. Lumber, usually the first material thought of that a tree is manufactured into, is still the leading raw material user. Plywood, hardboard, particleboard and insulation board, however, are growing in use, thereby demanding ever increasing amounts of raw material. Paper and pulp products, which we do not always relate to wood, command a tremendous amount of raw material usage.

These are engineered materials, ones that are designed to do specific jobs to exacting tolerances. They are materials that can be shaped, molded or formed into specific products.

We too often take for granted the many uses of wood products. It is important that both instructors and students of wood familiarize themselves with its importance, and with the various processes by which lumber and related products are manufactured. The complexity of the types, grades and sizes of wood products is not generally realized by the average person. It is for this reason that we have felt that a syllabus in lumber and related products would be helpful in developing programs, courses of study, or simply to aid in increasing understanding and effectiveness in teaching.

LUMBER AND RELATED PRODUCTS

I. Lumber grades and sizes

A. Purpose of grading

1. Lumber cut from logs will vary in appearance, strength and durability due to such characteristics as knots, checks, pitch pockets, shake and stain. The lumber is therefore grouped or graded according to the presence or absence of these characteristics, giving the buyer a more uniform product to meet his specific needs.

2. The classification of lumber into the various standard grades also insures the buyer of a more uniform lumber product from the different lumber manufacturers.

B. Lumber is divided into two classifications--hardwood and softwood

1. Hardwood is graded under rules governed by the National Hardwood Lumber Association.

   a) These grading standards generally are uniform throughout the United States and most of the world.

   b) There are some special grading rules set up by different industries for special uses such as flooring, pianos, etc.

2. Softwoods are graded under a number of different association rules and often the same specie is graded differently by the various associations.

C. Hardwood lumber grades and sizes

1. There are two classifications of hardwood lumber sold today.

   a) Factory lumber is used for remanufacture and is usually cut into several pieces to utilize the clear cuttings.

   b) Dimension stock is hardwood that has been specially made for a certain product (premanufactured). There are several classifications of dimension stock depending on the amount of manufacturing that has been performed on it.

      (1) Rough dimension - material that has been cut to a specific size but has had no other machining.

(2) Surfaced dimension - material that has been cut to a specific size but has had no other machining.

(3) Laminated dimension - several pieces having been glued together to a specific size.

(4) Fabricated dimension - material that has been completely machined and is ready for assembly.

2. Grading of hardwood factory lumber and dimension stock.

a) Steps that should be followed in grading factory lumber.

(1) Determine the species of wood being graded. Rules vary some in different species.

(2) Using a standard lumber scale stick determine the surface measure.

(3) Hardwoods are usually graded from the poor side. Therefore, determine the worst side of the board. (The one with the most defects or yielding the smallest cuttings.)

(4) Assume a grade for the board in question.

(5) Determine the number of cuttings and size of cutting for assumed grade.

(6) Check board in question to see if it will yield the number of clear cutting of the correct size to meet the grade.

(7) If it cannot make the grade, try for the next lower grade.

(8) For economic reasons it is always important for the grader to make the highest grade possible.

b) The grading of hardwood factory lumber.

(1) The lumber must be graded as it is found, not taking into consideration any upgrading resulting from recutting the board. Surface check and stain that will be removed when surfaced is taken into consideration. (Resawing is not considered).

(2) The lumber is separated into the following grades which are determined by the number of clear cuttings obtainable.*

(a) First - The highest grade of hardwood. This grade must yield 91 2/3% clear cutting.

(b) Seconds - The next grade requires 83 1/3% clear cuttings.**

(c) Select - The third grade of hardwood must have a face side that will yield the same cuttings as required for a F.A.S. and a poor face of no worse than a No. 1 common grade. The grading of the good face in select represents the only exception to the rule that the poor face determines the grade of hardwood.

(d) The remaining grades are No. 1 Common, Sound Wormy, No. 3A Common and No. 3B Common. These grades are used a great deal by producers who assemble products from fairly small clear cuttings which they can obtain from the somewhat lower grades.

c) The grading of hardwood dimension stock.

(1) Hardwood dimension lumber is graded as either flat stock or squares.

(a) Flat stock is separated into the following standard grades.

i) Clear - the wood will be clear on all faces and edges. Burl, wavy grain, and some sapwood stain is permitted but no knots, bark pockets, etc.

ii) Clear one face - the wood will be all clear except one face may contain defects of a sound nature.

iii) Paint - in this grade, defects are permitted on the best face as long as they can be covered by a nontransparent finish.

* Refer to "Short cut calculator" which gives details on size of cuttings, number of cuttings and other important information needed in determining the grades of hardwood.

** It should be noted that the first and second grades are almost always combined into one grade designated as F.A.S. (Firsts and Seconds).

"SHORTCUT" CALCULATOR

FOR HARDWOOD LUMBER GRADING

Grade	Percent Basic	Percent Extra	How to Obtain Cuttings	Number of Cuttings Basic	Number of Cuttings Extra	Multiply by Basic	Multiply by Extra	Number of Units Basic	Number of Units Extra	Min. Size Cuttings	Min. Size Board
FAS	83-1/3	91-2/3	SM/4			10	11			4" x 5' 3" x 7'	6"x8'
SEL	83-1/3	91-2/3	SM/4			10	11			4" x 5' 3" x 7'	4"x6'
#1 Com	66-2/3	75	SM+1/3			8	9			3" x 3' 4" x 2'	3"x4'
#2 Com	50	66 2/3	SM/2			6	8			3" x 2'	3"x4'
S.W. Oak only	66-2/3	75	SM+1/3			8	9			4" x 2' 3" x 3'	3x4'
#3A	33-1/3	50	U.L.			4				3" x 2'	3"x4'
#3B	25		U.L.			3				1-1/2" x 36 sq. in.	3"x4'

Note:

Max. No. of cuttings
- FAS - 4
- 1C - 5
- 2C - 7

Extra cutting
- FAS - 6' to 15'
- 1C - 3' to 7'
- 2C - 2' to 7'

ILLUSTRATED STANDARD HARDWOOD GRADES

Forsaking pinpoint accuracy for brevity, the following condensed grading explanation is nevertheless an excellent guide. For purposes of display, poorer boards illustrating limits were generally used in the following examples and as such are not to be construed as representative of the better stock also found in the same grade.

EXPLANATION

1. Like a thumb print, no two boards are exactly alike. As such, hardwoods are graded on percentage of yield in prescribed number of minimum size clear face cuttings.

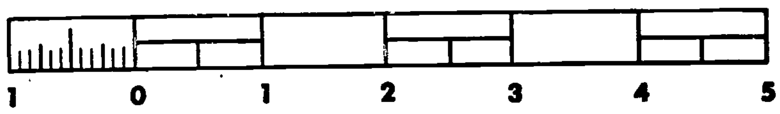
2. The following definitions apply to examples shown:
   Clear Face Cutting is clear one face. The reverse face to be free from heart pith, rot, shake, wane and unsound knots. **Surface Measure** is the square feet in the surface of any piece of any thickness.

3. In order of quality, the top three standard grades of hardwoods are:
   A. First & Seconds (FAS) B. Selects C. No. 1 Common

4. In rough lumber, the grade is determined from the poorer side of the piece, except when otherwise specified (see Selects). In surfaced lumber (clear face cutting grades), the grade is determined from the better face with reverse side of cuttings sound. (See definition of sound cutting in N.H.L.A. rules).

5. Shaded areas on examples may be clear, usable lumber, but for grading purposes are considered waste. On the FAS examples, the black area representing wane does not exceed 25% of the first lineal foot and the shaded area represents 50% or more clear wood in the first lineal foot, as required by N.H.L.A. rules for FAS.

Scale ½" = 1 foot



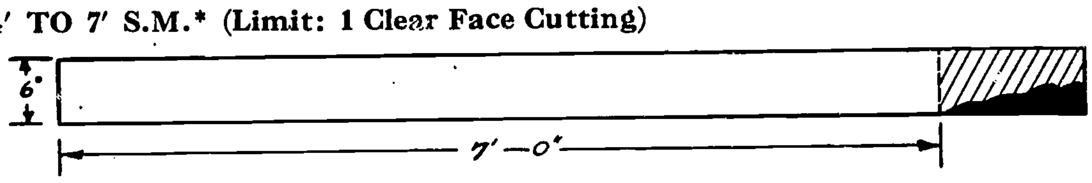
EXAMPLES

FIRSTS & SECONDS (FAS) GRADE

USE: For long, generally wide cuttings. As required for fixtures and interior trim.
BOARD SIZE: 6" and wider, 8' and longer. (See exceptions page 12.)
NO. OF CLEAR FACE CUTTINGS: Determined by Surface Measure (S M.) of piece. (See illustrations below.)

SIZE OF CLEAR FACE CUTTINGS: 4" or wider by 5' or longer and 3" or wider by 7' or longer.
YIELD IN BOARD OF CLEAR FACE CUTTINGS: 83⅓% (10/12s) or more.

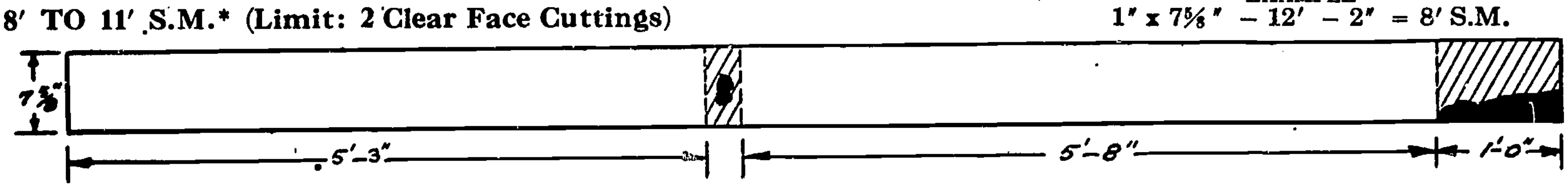
4' TO 7' S.M.* (Limit: 1 Clear Face Cutting)



EXAMPLE
1½" × 6" – 8' – 2" = 4' S.M.

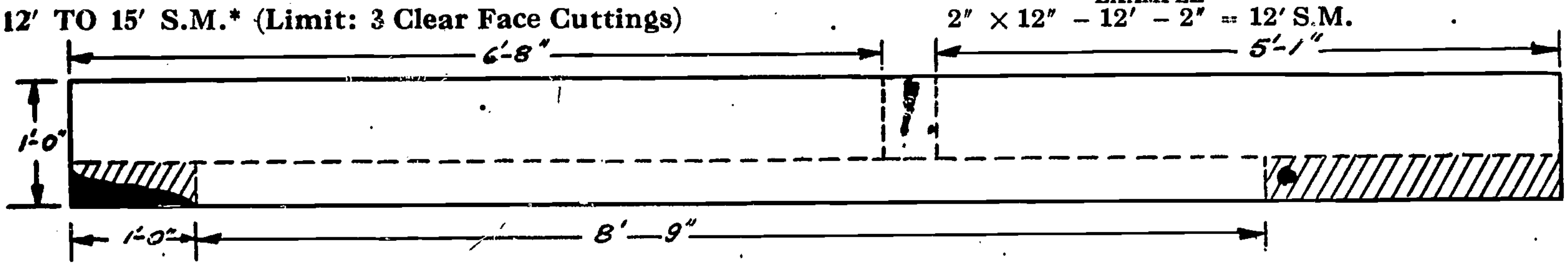
8' TO 11' S.M.* (Limit: 2 Clear Face Cuttings)

EXAMPLE
1" x 7⅝" – 12' – 2" = 8' S.M.



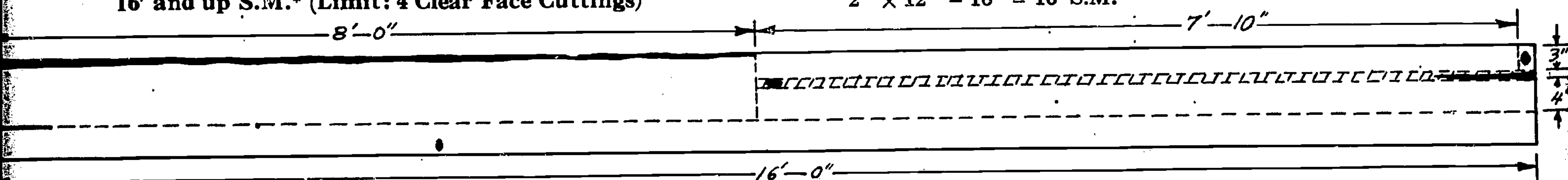
12' TO 15' S.M.* (Limit: 3 Clear Face Cuttings)

EXAMPLE
2" × 12" – 12' – 2" = 12' S.M.



16' and up S.M.* (Limit: 4 Clear Face Cuttings)

EXAMPLE
2" × 12" – 16' = 16' S.M.



OTE: 6' to 15' Surface Measure (S.M.) will allow 1 additional cut IF yield equals 91⅔% (11/12s) or more Clear Face Cuttings. *S.M. means Surface Measure.

iv) Core - the wood in this grade must be sound on both faces, but may have many types of defects. It should be noted that pieces making up the core may be end joined.

v) Sound - this grade permits any defect as long as it does not impair its strength too much.

(b) Dimension squares are separated into the following grades.

i) Clear squares - this is the top grade and clear on all faces, edges and ends.

ii) Select squares - will have two adjacent sides clear and 1/3 of the other two sides clear. The bottom 2/3 of the square must contain only small defects.

iii) Paint squares - these squares may have defects on all faces as long as they are sound and can be concealed by a non-transparent finish.

iv) Sound square - all defects are permitted as long as they do not weaken the material strength too much.

3. Sizes of Hardwood Lumber may vary from 4 to 16 feet in length, in multiples of one foot, and are random in width.

a) Dimension stock can usually be purchased in almost any size because much of it is custom manufactured.

b) Shown on the next page are the standard thicknesses of hardwood lumber.

D. Softwood lumber grades and sizes

1. Softwood lumber grades are not governed by a specific set of rules, but there is a different set of rules for each species or group of species. However, the recommendation of the American Lumber Standards for Softwood Lumber are used as a guide by such associations as the California Redwood Association, Western Pine Association, Southern Cypress Manufacture's Association, Northern Hemlock & Hardwood Manufacture's Association, Northeastern Lumber

STANDARD THICKNESSES FOR HARDWOOD LUMBER

Rough inches	Surfaced 1 side (S1S) inches	Surfaced 2 sides (S2S) inches	Rough inches	Surfaced 1 side (S1S) inches	Surfaced 2 sides (S2S) inches
3/8	1/4	3/16	2 1/2	2 5/16	2 1/4
1/2	3/8	5/16	3	2 13/16	2 3/4
5/8	1/2	7/16	3 1/2	3 5/16	3 1/4
3/4	5/8	9/16	4	3 13/16	3 3/4
1	7/8	1 3/16	4 1/2	*	*
1 1/4	1 1/8	1 4/16	5	*	*
1 1/2	1 3/8	1 5/6	5 1/2	*	*
2	1 13/16	1 3/4	6	*	*

* Finished size not specified in rules. Thickness subject to special contract. Source: U.S. Forest Service

Manufacture's Association, Western Red Cedar Association, Southern Pine Lumber Association and Western Wood Products Association to set up their grading standards.

2. The bases of grading softwood lumber is a board's freedom from blemishes or any defect that limits its use. Many of the defects are characteristic to each specie of lumber. One feature found much more abundantly in softwoods than in hardwoods is the amount of resin. Blue stain and mineral stain are also common in softwoods.

3. The American Lumber Standard has classified lumber into three classifications. These are not grading rules, but guides to help associations in setting up rules.

   a) Use Classification - Lumber is divided into three classes.

      (1) Yard lumber - lumber that is available at lumber yards for use in general construction.

      (2) Factory and Shop lumber - this lumber is usually cut up to be used in the manufacture of items where smaller pièces for trim, sash, casing, and other similar uses.

      (3) Structural Grades - These are heavier timbers and are used where strength is needed. They are seldom cut in use, except for length.

   b) Size Classification - Size classification has reference to rough green size. There are also three classifications in this category.

      (1) Boards - These are less than 2 inches thick and 1 inch or more wide. Boards less than 6 inches wide may be classified as strips.

      (2) Dimension - From 2 inches up to, but not including, 5 inches thick and 2 inches or more wide. These are often called framing, joints, planks, raters, studs, etc.

      (3) Timbers - Timbers are 5 inches or more in the smallest dimension. We refer to them as beams, stringers, girders, etc.

   c) Manufacturing Classification - The third American Lumber Standards classification is based on the amount of milling, surfacing, grooving, and other finish or work that is done on the lumber.

(1) Rough Lumber - Very little is done to this lumber. Basically, it has been cut on a rough saw and left with saw marks.

(2) Dressed (surfaced) Lumber - These boards are surfaced on one, two, three or four sides. Their size is usually uniform and may be designated as (SIS), (S2S), (S3S), and (S4S), referring to how many sides have been planed.

(3) Worked Lumber - After being planed or surfaced, worked lumber is matched by cutting tongue and grooves, shiplapping, or cutting some special pattern or shape.

d) Table of General Classification of Softwood Lumber
The following table shows the general use breakdown of softwoods. Yard lumber accounts for about 85% of this. (see table next page)

4. Grades of Softwood Lumber

a) Yard lumber is graded from the best face. The boards within a grade should be slightly better than the requirements because in most cases the minimum quality is described for each grade. A board, then, must have quality between its minimum grade requirements and the minimum requirements of the next grade higher.

In other cases, or in some species of softwood, grading rules are described for average or typical boards in a grade rather than quality based on minimum requirements.

(1) Select or Finish Lumber - is available in four grades.

(a) Grades A and B are generally grouped together and are called B and Better. Minor defects that are permitted in B and Better are planing skips, small spots of stain, minor seasoning checks, small pitch areas, pin knots and other blemishes. These defects and blemishes may vary some with species.

i) If graded separately grade A would be almost free of defects.

ii) Grades A and B or B and Better produce boards suitable for natural finishes and can be used where good appearance is desired.

(b) Grade C is also applicable to quality construction and works well for painted surfaces. The number of imperfections may amount to twice those allowed in B and Better. Grade C is limited to small knots, but more of them are allowed than in B and Better.

(c) Grade D can be used where paint is applied and still produce a board that does not detract from a good appearance. Even though grade D must yield a good paint surface, it is permitted to have an unlimited number of surface blemishes, as long as they do not transfer through the finish to the point of detracting from a good appearance.

(2) Common Boards - are graded with numbers from 1 through 5. In general, common grades have visual features that give a less desirable appearance but still leave the board good for utility purposes.

(a) Grade No. 1 - boards are sound, with tight knots of limited size. The knots may be of various types.

(b) No. 2 boards - allow the features of No. 1 plus some shake, through-pitch decay, and more knots.

(c) No. 3 boards - have larger and coarser knots than No. 2. No. 3 boards will allow knot holes and a greater amount of defects than found in No. 2, such as shake and decay.

(d) Grade No. 4 and No. 5 - are produced in only a few species. The quality is low, limiting the use and distribution. The particular association and the species they handle, will determine the number of grades manufactured, and the quality of each grade. This fact should be remembered when studying the general classifications.

(3) Common Dimension Lumber - Common dimension lumber is sold in 3 grades. Dimension lumber is also available in stress grades.
Since framing requirements are important for dimension lumber, features detrimental to strength are a major concern in grading.

(a) No. 1 dimension must be sound with a limit to the size of knots. The location of knots in a board affects its strength, so must be considered when grading. Other factors are less important if they do not tend to weaken the board.

(b) No. 2 dimension allows more defects than No. 1. It is used full length in most cases and must have strength for construction loads.

(c) No. 3 dimension is good for general utility use. No. 3 dimension is used for light or temporary construction. It also is often cut and used more economically.

b) Structural

(1) Strength is the prime factor in grading structural lumber. When better structural grades or larger sizes are needed they are cut to order. For long lengths structural lumber may be replaced by laminated beams

(2) Some of the structural lumber is stress graded by machines and then stamped. The grades for structural material are number 1 through 3. "Handbook No. 72" U.S. Department of Agriculture contains detailed material on stress grades and working stresses.

c) Factory and Shop Lumber

(1) Factory plank and shop lumber is graded under various association grading rules. These should be referred to for specific grades. Unlike most other softwood that is graded for entire board usage, much of factory and shop lumber grades are based on cuttings or the percentage of usable material of the boards. They are graded from the poor face.

(2) The cuttings are of two types. One is for clear cuttings which must be clear on both sides, at least 9 1/2 inches wide and 18 inches long. The second should be good on one side and at least 5 inches wide and 3 feet long.

d) Soft Wood Lumber Sizes

(1) Softwood lumber is usually manufactured in lengths of two feet multiples and width of 2 inch multiples.

(2) Some of the standard thickness and widths of softwood lumber are given in the table on the following page.

(3) Other size standards are listed in the Wood Handbook No. 72, U.S. Department of Agriculture, and in Lumber-The Stages and Manufacture from Sawmill to Consumer by Nelson C. Brown and James S. Bethal.

AMERICAN STANDARD THICKNESSES AND WIDTHS

TABLE

Item	Thickness		Widths	
	Nominal	minimum dressed	Nominal	minimum dressed
	Inches	Inches	Inches	Inches
	3/8	5/16	2	1 5/8
	1/2	7/16	3	2 5/8
	5/8	9/16	4	3 1/2
	3/4	11/16	5	4 1/2
	1	25/32	6	5 1/2
	1 1/4	1 1/16	7	6 1/2
Finish: Select or	1 1/2	1 5/16	8	7 1/4
Common	1 3/4	1 7/16	9	8 1/4
	2	1 5/8	10	9 1/4
	2 1/2	2 1/8	11	10 1/4
	3	2 5/8	12	11 1/4
	3 1/2	3 1/8	14	13
	4	3 1/2	16	15
Boards			5	4 5/8
			6	5 1/2
(In some regions			7	6 1/2
lumber thicker than			8	7 1/2
1 1/2 inch is graded			9	8 1/2
according to board			10	9 1/2
rules. When proper			11	10 1/2
provision is made			12	11 1/2
for this in the appli-			14	13 1/2
cable grading rules,			16	15 1/2
such lumber may be				
regarded as American				
standard lumber.)				
	2	1 5/8	2	1 5/8
Dimension, Plank	2 1/2	2 1/8	3	2 5/8
and Joists	3	2 5/8	4	3 5/8
	3 1/2	3 1/8	6	5 1/2
	4	3 5/8	8	7 1/2
			10	9 1/2
			12	11 1/2
			14	13 1/2
			16	15 1/2
			18	17 1/2
Timbers	5 (5 & thicker)	1/2 off	5 (5 & thicker)	1/2 off

GENERAL CLASSIFICATION OF SOFTWOOD LUMBER

Softwood lumber is divided into three main classes--yard lumber, structural lumber (often referred to under the general term "timber"), and factory of shop lumber. The following classification of softwood lumber gives the grade names in general use by lumber manufacturers' associations for the various classes of lumber.

Softwood lumber (This classification applies to rough or dressed lumber: sizes given are nominal)	Yard Lumber (lumber less than 5 in. thick, intended for general building purposes. grading based on use of the entire piece)	Finish (4 in. and under thick and 16 in. and under wide)		Grades A Select B Select C Select D Select
		Common boards (less than 2 in. thick and 1 inc. or more wide)		No. 1 boards No. 2 boards No. 3 boards No. 4 boards No. 5 boards
		Common dimension (2 in. and under 5 in. thick, and 2 in. or more wide)	Planks (2 in. and under 4 in. thick and 8 in. or more wide)	No. 1 dimension No. 2 dimension No. 3 dimension
			Scantling (2 in. and under 5 in. thick and less than 8 in. wide)	No. 1 dimension No. 2 dimension No. 3 dimension
			Heavy joists (4 in. thick and 8 in. or more wide)	No. 1 dimension No. 2 dimension No. 3 dimension
	Structural lumber (lumber 5 in. or more thick and wide, except joists and planks: grading based on strength and on use of entire piece)	Joists and planks (2 to 4 in. thick and 4 in. or more wide) Beams and stringers (5 in. or more thick and 8 in. or more wide) Posts and timbers (5 by 5 in. and larger)		
	Factory and Shop Lumber (grading based on area of piece suitable for cuttings of certain size and quality)	Factory plank graded for door, sash, and other cuttings (1 1/4 in. or more thick and 5 in. or more wide) Shop lumber graded for general cut-up purposes	Association grading rules should be referred to for standard grades and sizes	

Source: U.S. Forest Service

GLOSSARY OF TERMS RELATED TO GRADING OF LUMBER

Bark pocket - small patches of bark embedded between the annual growth rings.

Bird peck - a small hole or distortion of the grain resulting from birds pecking through the growing cells in the tree and is usually accompanied by discoloration along the grain.

Board foot - a board foot is the unit of measurement of lumber. A board foot is one foot long, one foot wide, and one inch thick, or its equivalent.

Bow - that distortion of a board in which the face is convex or concave longitudinally.

Burl - a swirl or twist in the grain of the wood which usually occurs near a knot but does not contain a knot, and is seldom considered a defect in grading of lumber.

Check - separation along the grain that usually develops during the seasoning because of the difference in radial and tangential shrinkage.

Crook - the lonitudinal distortion of a board in which the edge is convex or concave.

Cup - warping of the face of a board so that it assumes a convex or concave shape across the grain.

Cutting - the portion of a board used in determining the grades of lumber, and obtained by cross-cutting, ripping, or both. Generally considered the usable part of a board.

Decay (Dote) - decomposition of wood due to the attack of wood destroying fungi.

Defect - any irregularity which lowers the strength, or commercial value.

Grade - measurement of the quality of lumber which enables the purchaser to buy the quality which best suits his needs.

Hardwoods - wood produced by broadleaved trees and the term has nothing to do with the actual hardness of the wood.

Heartwood - the central part of the tree, the cells of which no longer participate in the life processes of the tree, and it is usually darker than the sapwood.

Honeycombing - internal splitting of the wood that developes during drying caused by internal stresses and is not often visible at the surface.

Knot - that portion of a branch or limb that has become incorporated in the body of a tree.

Mineral Streak - olive and greenish-black streaks caused by accumulation of mineral matter in concentrated areas. It is very common in maple and basswood.

Miscut lumber - lumber that is cut with a great deal of variation in thickness from the standard cut set up at the mill.

Pitch pocket - an opening extending parallel to the annual rings of growth usually containing, or which has contained, pitch, either solid or liquid.

Pith - the small, soft core occurring in the structural center of the tree. The board that contains the pith is called the dog board.

Pocket rot - advanced decay which appears in the form of a hole, pocket, or area of soft rot usually surrounded by apparently sound wood.

Sapwood - the outer portion of the tree that is living and is distinguished from the heartwood by being lighter in color.

Shake - a separation along the grain, the greater part of which occurs between the rings of annual growth.

Softwoods - wood produced by conifer trees. The term has no reference to the actual hardness of the wood.

Split - a lengthwise separation of the wood, due to the tearapart of the wood cells.

Stain, blue - a bluish or grayish discoloration of the sapwood caused by the growth of a dark-colored fungi.

Stain, brown - a discoloration of wood usually caused by chemical oxidation during the air drying or kiln drying of several species.

Twist - warping in which one corner of a piece of wood twists out of the plane of the other three.

Wane - bark or lack of wood.

Warp - any variation from a true plane surface. Warp includes bow, crook, cut, twist or any combination of these.

II. Veneer

Veneer is a thin sheet of wood of uniform thickness produced by peeling, slicing, or sawing logs, bolts, or flitches.

A. Manufacture of Veneers.

1. Rotary-cut veneer comprises approximately 90% of all veneer produced.

   a) Rotary-cut veneer is produced in a long continuous sheet of wood by literally unwinding the bolt on a veneer lathe (much as one would unroll a bolt of paper). The cut follows somewhat the annular growth rings.

   b) The principle adjustments made in setting up the lathe such as knife height, knife angle, vertical bar opening, and horizontal-bar opening determines to a large extent the quality of the veneer that is cut. Different species of wood requires a different setup on the lathe.

   c) Rotary-cut veneer is characterized by the presence of small lathe checks on that side of the veneer sheet that was originally nearest the center of the log.

   d) The hardwood plywood industry almost universally heats the log in hot water or steam to soften the wood so that a smoother cut can be made with a minimum of checking. Softwood plywood used this method until the invention of the roller nose bar.

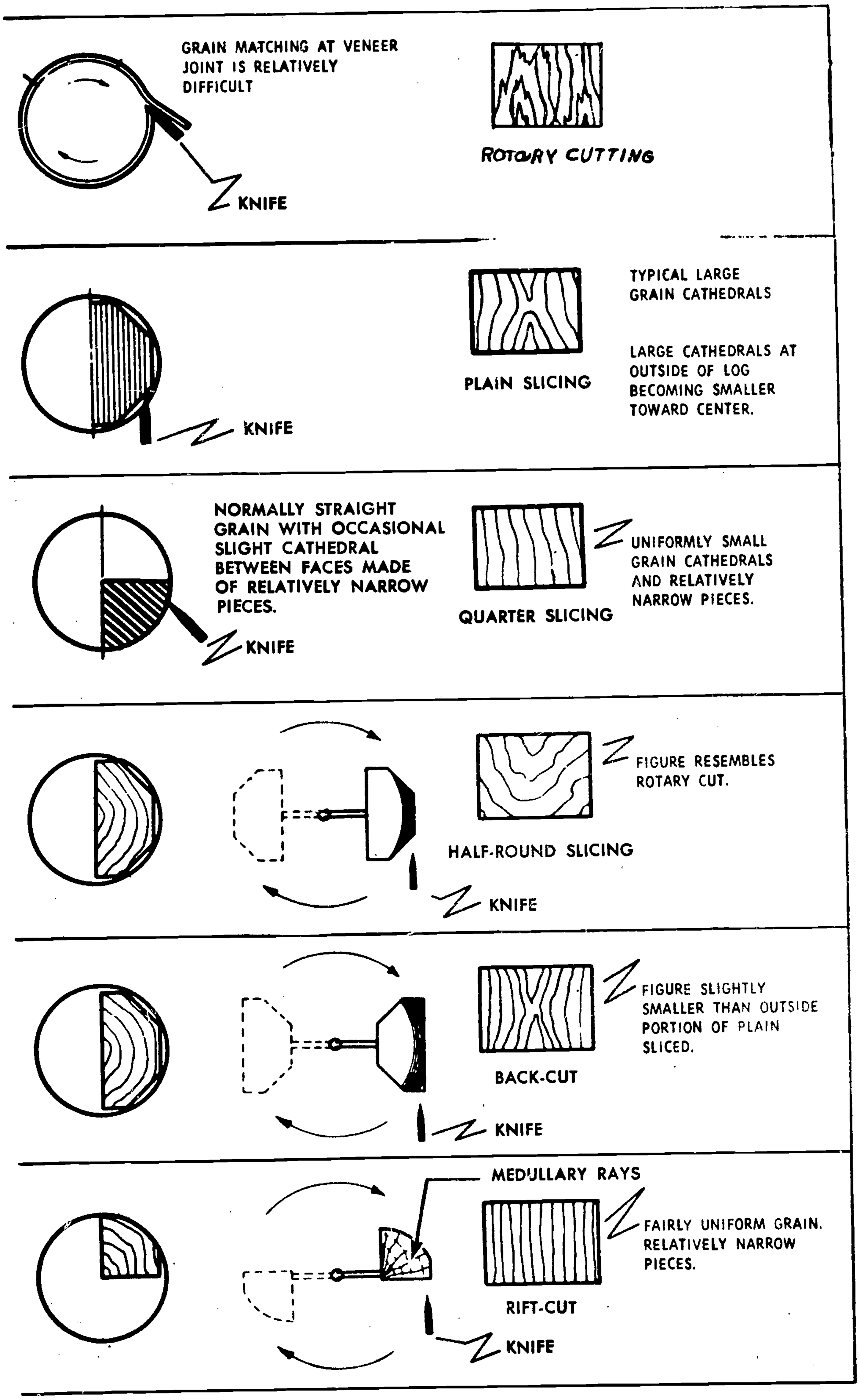
   e) The common practice of placing the tight side of veneer on the outside is facilitated by a marking device on the lathe which marks the nose bar side as it is being cut.

2. Stay-log cutting is similar to rotary cutting. This consists of what might be called a half-round cut on quarter flitches, burls, crotches, and stumps to produce fancy faced veneers.

3. Cone-cutting produces circular sheets of veneer by taper-peeling a bolt similar to the sharpening of a pencil. This method produces a veneer that is "short-grained" and very brittle, therefore, only a very small amount of veneer is produced by this method. The veneer sheets form a large circle and are used primarily in the fabrication of circular table tops.

4. Sliced veneer, which may be of all species, is used for cutting figured wood for face veneer.

   a) This method was developed to eliminate the wasteful practice of sawing veneer.


GRAIN MATCHING AT VENEER JOINT IS RELATIVELY DIFFICULT
KNIFE
ROTARY CUTTING
TYPICAL LARGE GRAIN CATHEDRALS
LARGE CATHEDRALS AT OUTSIDE OF LOG BECOMING SMALLER TOWARD CENTER.
PLAIN SLICING
KNIFE
NORMALLY STRAIGHT GRAIN WITH OCCASIONAL SLIGHT CATHEDRAL BETWEEN FACES MADE OF RELATIVELY NARROW PIECES.
UNIFORMLY SMALL GRAIN CATHEDRALS AND RELATIVELY NARROW PIECES.
QUARTER SLICING
KNIFE
FIGURE RESEMBLES ROTARY CUT.
HALF-ROUND SLICING
KNIFE
FIGURE SLIGHTLY SMALLER THAN OUTSIDE PORTION OF PLAIN SLICED.
BACK-CUT
KNIFE
MEDULLARY RAYS
FAIRLY UNIFORM GRAIN. RELATIVELY NARROW PIECES.
RIFT-CUT
KNIFE

b) Radial and flat-cut veneer both are produced by the slicing method. The machine operator makes the decision as to which type is cut.

c) The vertical type slicer is the most commonly used slicer in the United States. Most European sliced veneer is produced on a horizontal type slicer.

5. Sawing veneer wastes such large amounts of wood that this method is used very little at the present time. This method is restricted to woods that are unsuitable for slicing or woods that cannot be softened without imparing their color.

6. Veneer thickness range from 1/110" to 3/8".

a) Rotary-cut veneer generally is 1/7, 1/8, 1/10, 1/16, or 1/20 inch thick.

b) Sliced veneers usually range from 1/20 to 1/40 of an inch thick. The majority of face veneers are 1/20, 1/28, or 1/32 of an inch thick.

c) Sawed veneer ranges from 1/4 to 1/32 of an inch thick. The most common thickness being 1/20 inch thick.

7. Green-clipping is done to reduce the large sheet of veneer to rough dimensional size behind the lathe. Defects also may be removed during this operation. Since this is a relatively continuous operation, it requires special veneer handling operations between the lathe and green clipper.

a) Stack-and-bulk-clip is the oldest method of handling rotary-cut veneer behind the lathe.

b) Storage-deck method was developed by the softwood plywood industry to permit single sheet drying and clipping. When using this method, the defects are removed at the dry-clipper.

c) Reeling method in which the veneer is rolled onto a reel for storage before clipping was developed in Europe and became popular in America after World War II.

B. Drying of veneers is necessary to prevent damage by staining, mold, and fungi as soon and rapidly as possible after being cut because of the high moisture content required during the cutting operation. Several methods are used depending on the ultimate use of the stock and the facilities available.

1. Air drying is practiced in the cheaper grades of veneer. The veneer is put on stickers or stacked on end in finger racks to permit face air circulation.

2. Loft drying is used in some instances where-by the veneer is hung on clips from rafters or edge stacked in finger racks until the veneer stabilizes.

3. Kiln-drying in progressive and compartment kilns is practiced where-by the veneer is bulk stacked between stickers. Approximately 48 hours is used by some plants to dry 1/8" rotary-cut red gum stacked with ten sheets between stickers.

4. Veneer dryers especially designed for drying veneer are used to dry most of the veneer produced.

   a) Conveyor driers are long chambers equipped with heating units and power drier rolls which move the veneer through them.

   b) Hot-plate driers commonly referred to as plate driers or plate-redriers consist of a battery of heated plattens which close to apply heat and pressure on the veneer. They open intermittently to allow moisture to escape.

   c) A combination of the conveyor and hot-plate driers is also used where-by the conveyor stops when the plattens close and move when the plattens open.

   d) Continuous-type, high temperature driers are used to dry most of the veneers in the U. S.

5. Drier operations require adequate control over all variables in the drying process. Bethel pointed out seven variables subject to control in the normal drying operation.

   a) Variables in the drying operation includes:

      (1) initial moisture content of green veneer

      (2) species

      (3) thickness

      (4) heartwood or sapwood conditions.

C. Grading and types of veneer necessitate a further division of the veneer industry into hardwood and softwood veneer. This distinction is necessary because of the marked difference in utilization of their products.

1. The hardwood-veneer industry makes a further distinction in their product. These include: face veneer, commercial veneer, and container veneer. These groups refer to the use of the veneer although the grades which will be discussed later may reflect the uses also.

   a) Face-veneer manufacturers usually use the slicing, sawing, or stay-dog cutting methods on selected logs, burls, crotches, and stumps to produce the fancy face veneers. The veneer is is dryed, marked, and stored in flitches until sold for face stock. Samples are taken from each flitch for inspection by prospective buyers.

   b) Commercial veneer, or "Utility" veneers are used as cross-bands, cores, and backs of plywood panels, and concealed parts of furniture. These veneers are usually cut by the rotary method. Generally the manufacturer cuts an order with specifications as to species, thickness, sheet size, and grade. Most commercial veneer is sold to furniture, piano, or radio manufacturers.

   c) Container veneer consists of a variety of cheap veneers suitable for crates, fruit and vegetable baskets, cheese boxes and other similar items.

2. The softwood veneer is used mainly by the softwood plywood industry, however, it is also used by the hardwood plywood industry as centerstock in hardwood panels.

D. Grades of veneer in the veneer industry differ in each of the major classifications; hardwood and softwood.

   1. Hardwood veneers are graded 1, 2, 3, and 4 in order of descending quality.

   2. Softwood veneers are graded N, A, B, C, C (plugged), and D in order of descending quality as shown on the following page.

Veneer grades used in plywood

(Summary . . . see PS 1-66 for complete specifications.)

Veneer Grade	Defect Limitations	
N Intended for Natural Finish	Presents smooth surface. Veneer shall be all heartwood or all sapwood free from knots, knotholes, splits, pitch pockets, other open defects, and stain, but may contain pitch streaks averaging not more than 3/8" wide blending with color of wood. If joined, not more than two pieces in 48" width; not more than three pieces in wider panels. Joints parallel to panel edges and well-matched for color and grain. Repairs shall be neatly made, well-matched for color and grain, and limited to a total of six in number in any 4' x 8' sheet.	• Maximum of three "router" patches not exceeding 3/4" x 3-1/2" admitted. No overlapping. • Shims admitted not exceeding 12" in length but may occur only at ends of panel. (Examples of permissible combinations: 3 router patches and 3 shims, 2 router patches and 4 shims, 1 router patch and 5 shims, or 6 shims). Suitable synthetic fillers may be used to fill 1/32" wide checks, splits up to 1/16" x 2", and chipped areas or other openings not exceeding 1/8" x 1/4".
A	Presents smooth surface. Admits—Pitch streaks blending with color of wood and averaging not more than ⅜" in width. —Sapwood. —Discolorations. Veneer shall be free from knots, knotholes, splits, pitch pockets and other open defects. If of more than one piece, veneer shall be well joined. Repairs shall be neatly made, parallel to grain, and limited to 18 in number in any 4' x 8' sheet, excluding shims; proportionate limits on other sizes.	Patches of "boat," "router," and "sled" type only, not exceeding 2-1/4" in width, and may be die-cut if edges are cut clean and sharp. Radius of ends of boat patches shall not exceed 1/8". • Multiple patching limited to 2 patches, neither of which may exceed 7" in length if either is wider than 1". • Shims admitted except over or around patches or as multiple repairs. Suitable synthetic fillers may be used to fill 1/32" wide checks, splits up to 1/16" x 2", and chipped areas or other openings not exceeding 1/8" x 1/4".
B	Presents solid surface. Admits—Knots up to 1" across the grain if both sound and tight. —Pitch streaks averaging not more than 1" in width. —Discolorations. —Slightly rough but not torn grain, minor sanding and patching defects, including sander skips not exceeding 5% of panel area. Veneer shall be free from open defects except for splits not wider than 1/32", vertical holes up to 1/16" in diameter if not exceeding an average of one per square foot in number, and horizontal or surface tunnels up to 1/16" in width and 1" in length not exceeding 12 in number in a 4' x 8' sheet (proportionately on other sizes).	Repairs shall be neatly made and may consist of patches, plugs, synthetic plugs and shims. • Patches may be "boat," "router," and "sled" type not exceeding 3" in width individually when used in multiple repairs or 4" in width when used as single repairs. • Plugs may be "circular," "dog-bone," and "leaf-shaped," not exceeding 3" in width when used in multiple repairs or 4" in width when used as single repairs. • Synthetic plugs shall present a solid, level, hard surface not exceeding above dimensions. Suitable synthetic fillers may be used to fill small splits or openings up to 1/16" x 2", and chipped areas or other openings not exceeding 1/8" x 1/4".
C	Admits—Tight knots up to 1½" across the grain. —Knotholes not larger than 1" across the grain. Also an occasional knothole not more than 1½" measured across the grain, occurring in any section 12" along the grain in which the aggregate width of all knots and knotholes occurring wholly within the section does not exceed 6" in a 48" width, and proportionately for other widths. —Splits ½" by one-half panel length; ⅜" by any panel length if tapering to a point; ¼" maximum where located within 1" of parallel panel edge. —Worm or borer holes up to ⅝" x 1½".	Repairs shall be neatly made and may consist of patches, plugs, and synthetic plugs. Patches ("boat," including die-cut) not exceeding 3" in width individually when used in multiple repairs or 4" in width when used as single repairs. Plugs may be circular, "dog-bone" and leaf-shaped. Synthetic plugs shall present a solid, level, hard surface not exceeding above dimensions.
C (plugged)	Admits—Knotholes, worm or borer holes, and other open defects up to ¼" x ½". —Sound tight knots up to 1½" across the grain. —Splits up to ⅛" wide.	—Ruptured and torn grain. —Pitch pockets if solid and tight. —Plugs, patches and shims.
D	D veneer used only in Interior type plywood and may contain plugs, patches, shims, worm or borer holes. Backs: Admits tight knots not larger than 2½" measured across the grain and knotholes up to 2½" in maximum dimension. An occasional tight knot larger than 2½" but not larger than 3" measured across the grain or knothole larger than 2½" but not larger than 3" maximum dimension, occurring in any section 12" along the grain in which the aggregate width of all knots and knotholes occurring wholly within the section does not exceed 10" in a 48" width and proportionately for other widths. Inner Plys: Knotholes limited as for backs.	All Plys: Pitch pockets not exceeding 2-1/2" measured across the grain. Splits up to 1" except in backs only not more than one exceeding 1/2"; not exceeding 1/4" maximum width where located within 1" of parallel panel edge; splits must taper to a point. White pocket in inner plys and backs, not exceeding three of the following characteristics in any combination in any area 24" wide by 12" long. (a) 6" width heavy white pocket. (b) 12" width light white pocket. (c) One knot or knothole or repair 1-1/2" to 2-1/2", or two knots or knotholes or repairs 1" to 1-1/2".

Grade-use guide for engineered grades of plywood

Type	Use these symbols when you specify plywood (1) (2)	Description and Most Common Uses	Typical Grade-trademarks	Veneer Grade: Face	Veneer Grade: Back	Veneer Grade: Inner Plys	Most Common Thickness (inch) (3)							
Interior Type	STANDARD INT-DFPA	Unsanded Interior sheathing grade for subflooring, wall sheathing and roof decking.	STANDARD 32/16 INTERIOR DFPA	C	D	D		5/16	3/8	1/2	5/8	3/4	7/8	
Interior Type	STANDARD INT-DFPA (with exterior glue)	Same as STANDARD sheathing but has exterior glue. For construction where unusual moisture conditions may be encountered.	STANDARD 32/16 INTERIOR DFPA EXTERIOR GLUE	C	D	D		5/16	3/8	1/2	5/8	3/4	7/8	
Interior Type	STRUCTURAL I and STRUCTURAL II INT-DFPA	Unsanded structural grades where plywood strength properties are of maximum importance. Structural diaphragms, box beams, gusset plates, stressed-skin panels. Made only with exterior glue. STRUCTURAL I limited to Group 1 species for face, back and inner plys. STRUCTURAL II permits Group 1, 2, or 3 species.	STRUCTURAL I 32/16 INTERIOR DFPA EXTERIOR GLUE	C	D	D		5/16	3/8	1/2	5/8	3/4	7/8	
Interior Type	UNDERLAYMENT INT-DFPA (4)	For underlayment or combination subfloor-underlayment under resilient floor coverings, carpeting. Used in homes, apartments, mobile homes, commercial buildings. Ply beneath face is C or better veneer. Sanded or touch-sanded as specified.	UNDERLAYMENT GROUP 1 INTERIOR DFPA	C Plugged	D	C & D	1/4		3/8	1/2	5/8	3/4		
Interior Type	C-D PLUGGED INT-DFPA (4)	For utility built-ins, backing for wall and ceiling tile. Not a substitute for Underlayment. Ply beneath face permits D grade veneer. Unsanded or touch-sanded as specified.	C-D PLUGGED GROUP 2 INTERIOR DFPA	C Plugged	D	D		5/16	3/8	1/2	5/8	3/4		
Interior Type	2-4-1 INT-DFPA (5)	Combination subfloor-underlayment. Quality base for resilient floor coverings, carpeting, wood strip flooring. Use 2-4-1 with exterior glue in areas subject to excessive moisture. Unsanded or touch-sanded as specified.	2·4·1 GROUP 2 INTERIOR DFPA	C Plugged	D	C & D								1-1/8
Exterior Type	C-C EXT-DFPA	Unsanded grade with waterproof bond for subflooring and roof decking, siding on service and farm buildings.	C-C 32/16 EXTERIOR DFPA	C	C	C		5/16	3/8	1/2	5/8	3/4	7/8	
Exterior Type	C-C PLUGGED EXT-DFPA (4)	Use as a base for resilient floors and tile backing where unusual moisture conditions exist. For refrigerated or controlled atmosphere rooms. Sanded or touch-sanded as specified.	C-C PLUGGED GROUP 4 EXTERIOR DFPA	C Plugged	C	C	1/4		3/8	1/2	5/8	3/4	7/8	
Exterior Type	STRUCTURAL I C-C EXT-DFPA	For engineered applications in construction and industry where full Exterior type panels made with all Group 1 woods are required. Unsanded.	STRUCTURAL I C-C 32/16 EXTERIOR DFPA	C	C	C		5/16	3/8	1/2	5/8	3/4	7/8	
Exterior Type	B-B PLYFORM CLASS I & II EXT-DFPA	Concrete form grades with high re-use factor. Sanded both sides. Edge-sealed, and mill-oiled unless otherwise specified. Special restrictions on species. Also available in HDO.	B-B PLYFORM CLASS I EXTERIOR DFPA	B	B	C					5/8	3/4		

NOTES:

(1) All Interior grades shown also available with exterior glue.

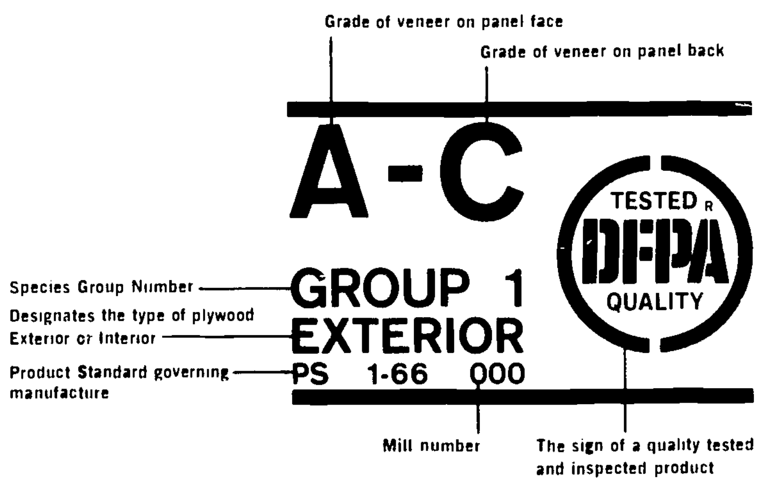
(2) All grades except Plyform available tongue and grooved in panels 1/2" and thicker.

(3) Panels are standard 4x8-foot size. Other sizes available.

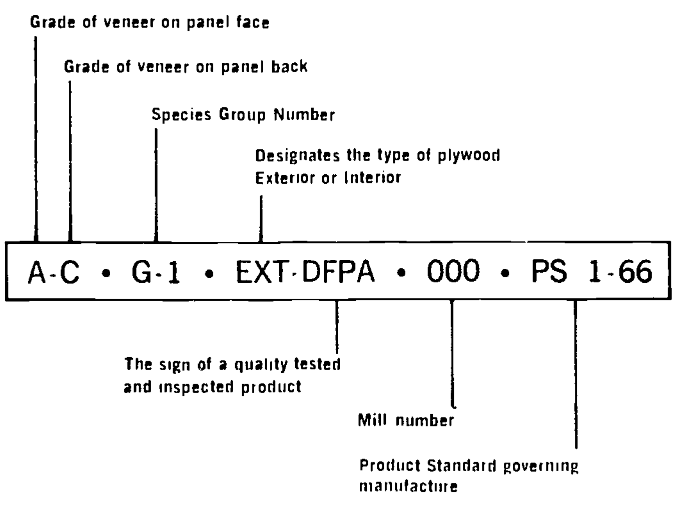
(4) Available in Group 1, 2, 3 or 4.

(5) Available in Group 1, 2 or 3 only.

Typical Back-stamp



Typical Edge-mark



e) Taping and splicing may be accomplished by hand or by special machines. Two types of machines are used in this process. One uses a strong tape over the glue line which will be sanded off later. The tapeless splicer which is a more recent development permits edge gluing veneer without the use of tape. This is a definite advantage since there is no tape to be sanded off later.

f) The face plies are inspected following the splicing operation to assure that they comply with grade standards. Small defects that may be detected may be patched at this time or if warranted sent back for reprocessing.

(1) High-priced cabinet woods are repaired by hand by highly skilled craftsmen.

(2) The softwood-plywood is normally repaired by patching. The patches take a variety of shapes, including circular, oval, elliptical, lenticular, and dog-bone shape.

2. Preparation of solid core stock is another step necessary in the manufacturing of plywood that is not made entirely of veneer. The hardwood-plywood industry is the major user of solid core material.

a) Lumber is used for making most of the solid core stock and is commonly made up of kiln dried factory-grade dimension stock. The preparation process simply consists of cross-cutting to length eliminating the major defects, ripping the stock to assure a straight edge and gluing to the proper width.

b) Particle board is another material used for solid core plywood. Essentially the only preparation necessary is cutting to size.

3. A number of adhesives may be used in the manufacture of plywood. These include both natural and synthetic glues. The type used depends on the performance of the glue under the conditions regulated by the ultimate use of the plywood. A plywood panel is no better than its glue bond.

a) Phenol-formaldehyde-resin is used primarily for exterior plywood by the softwood-plywood industry.

b) Urea-formaldehyde-resin is used primarily for interior plywood by the softwood-plywood industry.

III. Plywood

Plywood is a term applied to glued wood constructions built up of veneer layers so that the grain of each layer is at a right angle to that of the adjacent layer in the assembly. This method of assembling is referred to as cross-banded construction. It is this cross-banded construction that distinguishes plywood from laminated wood. Plywood offers distinct advantages over solid wood. Some of the more important advantages are: dimensional stability is improved, strength properties are modified, and wood characteristics are rearranged to maximum advantage.

A. The manufacture of plywood varies considerably. Softwood plywood plants differ from hardwood plywood plants in many respects, however in general, the basic operations are common to all plywood-manufacturing enterprises. They consist essentially of preparing the stock for gluing, mixing and spreading glue, pressing, and finishing.

1. The preparation of veneer stock for gluing depends on the quality of panel being produced. This operation in any plywood plant consist essentially of converting sheets of dry veneer or solid core stock into plys that conform to certain specifications with respect to size and grade.

a) Grading and matching is of great importance in the preparation of face plies.

(1) Matching is necessary only if the width of the plywood panel is such that it requires that the veneer be edge glued to cover the panel.

(2) For standard stock panels of either hardwood or softwood, veneer must be graded even though matching is not required.

b) Redrying is necessary since the initial drying process sometimes leaves the veneer with a moisture content higher than is applicable to gluing.

c) Dry-clipping is a process used to square and cut the veneer to size. This may be accomplished either one sheet at a time, or an entire flitch; if using veneer that was produced by slicing or stay-log methods.

d) Jointing produces a straight square edge on the veneer so that two sheets can be taped or spliced together to provide a good joint line. The glue may be applied in the jointing operation with a glue spreader mounter on the jointer behind the cutterhead.

c) Further information on adhesives can be found in the adhesive section.

4. Proper adhesive mixing is necessary in order to obtain maximum results from the adhesive. Follow the manufacturers instructions is the best policy. The adhesives are mixed in a dough-type mixer. The quantity is determined by the properties of the material. Adhesives with a short open time must be prepared in small batches.

5. A glue spreader is normally used to apply glue to the veneer in the manufacture of plywood. The spreader may consist of two power driven rolls to which glue is applied. The veneer is passed between the rolls and glue is applied. It is consistent with good gluing practice to use no more than the required minimum of an adhesive in making a joint.

6. Pressing is necessary in the manufacture of plywood to ensure proper alignment of the components and an intimate contact between the wood and the glue.

   a) Cold-pressing (room temperature) is used with the natural glues and some urea-formaldehyde.

      (1) The clamping method is one type used in the cold-pressing. The panels are loaded into the press with I-beams below and above the panels. Retaining clamps are attached to the I-beams and tightened as pressure is applied. This allows the panels to be removed from the press before the glue has cured. This is a more economical method since the press is free for another load.

      (2) The no-clamp method means simply that the panels are left in the press until cured.

   b) Hot-presses consisting of heated plattens are also used in the manufacture of plywood. These presses will hold up to 20 panels and are operated hydroulically. Pressing time varies from 2 - 30 minutes depending on the thickness of the stock, the platten opening, type of adhesive, curing temperature, and degree of cure. Temperatures of 230^{o} to 350^{o} F. are commonally used in hot pressing.

7. Plywood may be molded if the situation demands a stable curved product. Thin panels may also be molded.

8. Redrying is usually necessary after the cold-pressing since moisture is added during the gluing process. 10 to 15% M.C. is recommended for exterior use while 7 to 8 % M.C. is recommended for interior plywood.

9. Finishing the manufacture operations of the panels consist of the edges being trimmed to exact size. Sanding the faces removes tape, rough spots and uneveness in thickness. Care must be taken to assure that both faces are sanded equally otherwise the symmetry of the board may be lost. After sanding, the panels undergo a final inspection and grading before being stored or shipped.

C. Types and grades differ in the softwood hardwood plywood industry.

1. Hardwood types are listed below:

   a) Technical-provides a fully waterproof bond. The construction is designed to provide approximately equal tension and compression strength in the two directions of length and width.

   b) Type I (Ext.) - provides fully waterproof bond

   c) Type II(Int.) - provides water resistant bond

   d) Type III (Int.) - provides moisture-resistant bond

2. The grade designates the quality of the face, back, or inner plies.

   a) Premium grade (1) infers face shall be of the species of hardwood specified and each face shall be of tight and smoothly cut veneer.

   b) Good grade (1) - (for natural finish) requires that the face shall be made of tight smoothly cut veneers.

   c) Sound grade (2) - (for smooth paint surfaces) requires that the face shall be free from open defects to provide a sound, smooth surface.

   d) Utility grade (3) - permits small knot holes (3/4" maximum) patches, stain, small splits and small areas of rough grain.

   e) Backing grade (4) - permits knot holes up to 2 inch diameter, splits up to 1 inch wide and 1/4 panel length.

   f) Specialty grade (SP) - includes plywood that does not conform to any of the above grades, such as architectural plywood, notched-grain panels for special uses and special veneer selections.

3. Softwood-plywood is manufactured in two types, exterior and interior.

   a) Exterior type contains glue lines that are 100 per cent waterproof. Specify exterior type for all exposed applications.

   b) Interior type contains highly moisture resistant glue lines. The inner plies of veneer are of lower grade than exterior types.

4. Softwood-plywood is graded on two characteristics; appearance and performance.

   a) The appearance grades can be found on the last page of the veneer section of this book.

   b) Performance grades reflect the primary use for which the panel is made. (examples are plyform used in concrete forms and underlayment used in floors.)

   c) The product standard is a performance standard designed to present a clear understanding between buyer and seller.

      (1) To identify plywood manufactured by Association member mills, under the requirements of Product Standard P.S. 1-66, ten types of grade trademarks are used to illustrate the plywood's type, grade, group, class, and identification index.

      (2) The following table lists the grade and trademarks together with notations on what each element means:

IV. Fiberboard

Fiberboard (under the family of composition board) is essentially wood fibers processed into pulp and pressed into sheets and is graded according to density, from insulating board to the pressed hardboards. In this process, heat and pressure causes the felting of the fibers and the bonding of the natural lignin to form the board.

A. Fiberboard is divided into two classifications.

1. Insulation board which is outlined in Roman Numeral VII of this booklet.

2. Hardboard is an engineered wood product made from clean logs that have been converted to chips and wood fibers. These fibers are then permanently bonded together under heat and pressure with the natural lignin of the wood serving as the binder. The mingling and interlocking of the fibers gives characteristics of density, grainless structure, uniformity in appearance, strength against cracking, checking, chipping, splitting, etc.

    a) The discovery of hardboard was in 1924 at Laurel, Mississippi, by William H. Mason.

    b) Today the United States produces about one-third of the world's 8 billion square feet used each year.

    c) Hardboard may be used either as an interior or exterior product. Some of the interior applications are storage, cabinets, draweres, ceilings merchandise racks, wall panels, sliding doors, and many others. Some exterior applications would include concrete forms, siding, fences, shutters, boats, trailers, signs, and small houses.

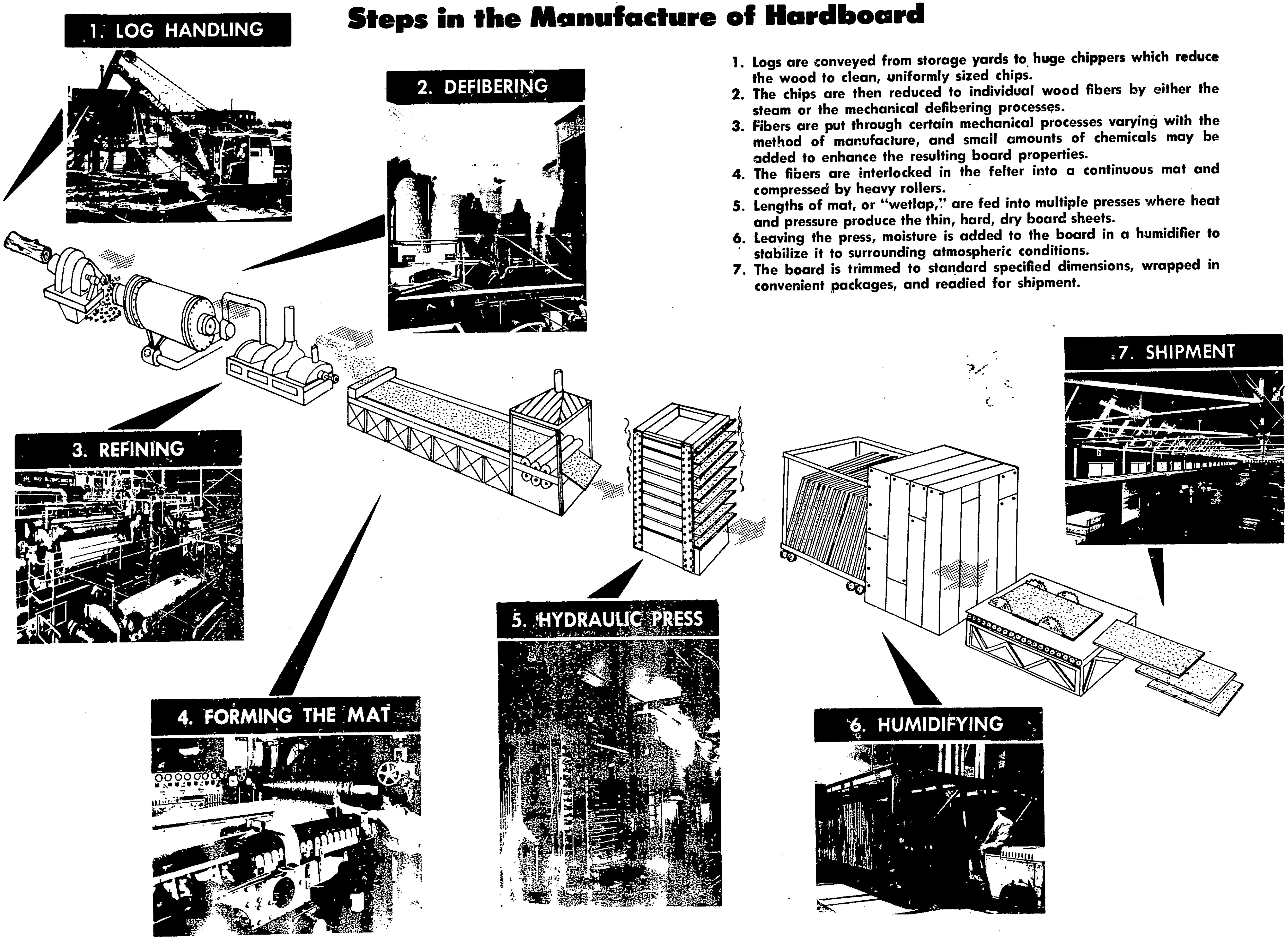
B. Manufacturing of hardboard

1. Logs are conveyed from storage yards to huge chippers which reduce the wood to clean, uniformly sized chips. These chips usually measure about five eighths of an inch wide and one inch long. Various kinds of wood can be used to make these chips. Residues (scrape and waste) from sawmills and plywood plants are used extensively.

2. The chips are then reduced to individual wood fibers by either the steam or the mechanical defibering processed.

Steps in the Manufacture of Hardboard

1. Logs are conveyed from storage yards to huge chippers which reduce the wood to clean, uniformly sized chips.
2. The chips are then reduced to individual wood fibers by either the steam or the mechanical defibering processes.
3. Fibers are put through certain mechanical processes varying with the method of manufacture, and small amounts of chemicals may be added to enhance the resulting board properties.
4. The fibers are interlocked in the felter into a continuous mat and compressed by heavy rollers.
5. Lengths of mat, or "wetlap," are fed into multiple presses where heat and pressure produce the thin, hard, dry board sheets.
6. Leaving the press, moisture is added to the board in a humidifier to stabilize it to surrounding atmospheric conditions.
7. The board is trimmed to standard specified dimensions, wrapped in convenient packages, and readied for shipment.



a) The mechanical process tears the chips apart and reduces them to fiber bundles.

b) The steam pressure process which causes the chips to explode and become a fine, fluffy, brown mass of fibers covered with a film of lignin.

3. Refining takes place at this point to reduce the fiber bundles to individual fibers. Small amounts of chemicals may be added to enhance the resulting properties of the board. Among the binding agents and other materials that may be added are rosin, alum, asphalt, paraffin, synthetic and natural resins, preservative and fire-resistant chemicals, and drying oils.

4. Mat forming takes place next by one of two ways, wet process or dry process. After the mat is formed it is compressed by heavy rollers to a thickness and weight that is ready to be loaded into the press.

   a) In the wet process the fibers are mixed with water and fed to a screen to form a mat. The excess water is then removed, leaving the fibers as a mat ready for the press.

   b) Dry process uses the air-suspension method, fibers are blown into a cone, where they settle, forming a mat.

5. Hydraulic pressing (in a multiple press) is where heat and pressure are applied to the mat resulting in a thin grainless dry board.

   a) Pressure within the press may reach several hundred pounds per square inch depending on the type board required.

   b) The platens, which are steam heated to speed up the process and make the resins harden, may reach temperatures of 330°F.

   c) Up to twenty mats may be handled in a large press at one time.

6. The humidification chamber is designed to take the dry board and stabilize it to the surrounding atmosphere conditions. This operation prevents the board from warping.

7. Trimming and packaging are the last steps in the manufacturing process of standard hardboard.

   a) Boards are trimmed to standard specified dimensions, wrapped, and readied for shipment.

   b) The standard thickness of sheets is 1/12, 1/10, 1/8, 3/16, 1/4, and 3/8 in most grades.

   c) The standard widths are 3, 4, and 5 feet.

   d) The standard lengths are 4, 6, 8, 12, and 16 feet.

C. Types of Hardboard

1. Standard hardboard is made by the standard hardboard process without any added treatments. It may be used where there will be no unusually hard wear or extreme humidity.

2. Tempered hardboard is similar to standard hardboard, but it has chemicals added. It is then heat-treated resulting in an extra hard surface and a high resistance to weather and moisture.

3. Service hardboard is of moderate strength somewhat less than that of standard. It is suitable for general use and is a typical board for interior paneling. This is a product of lower density than standard hardboard and for this reason has better dimensional stability than the more dense products.

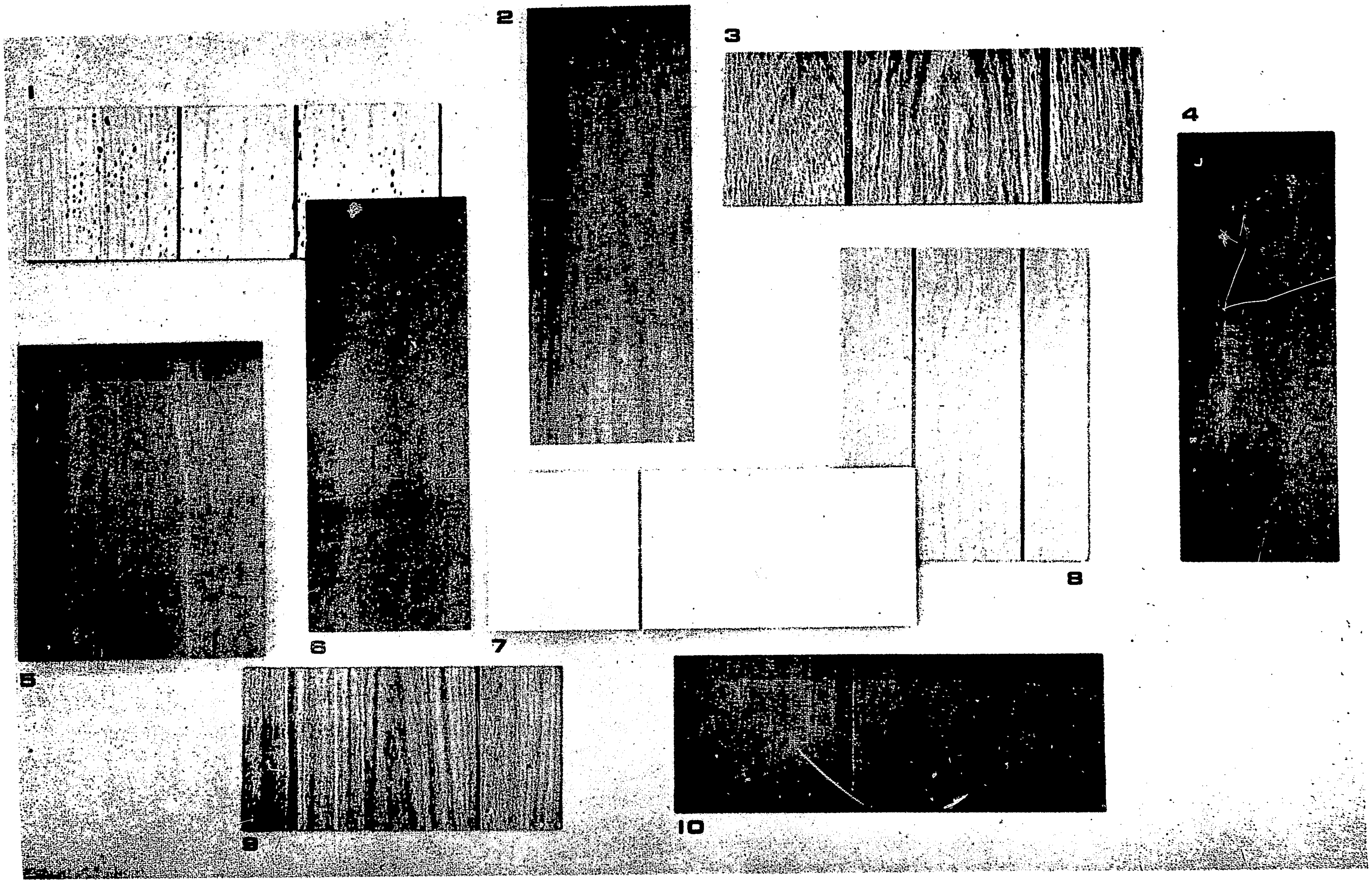
D. Hardboard grades, special textures and special applications

1. The most common surface is one side smooth and one side rough, this is designated SIS. Less common but is used, is a type with both sides smooth, this is designated S2S.

2. The most common textures found in hardboard are striated, grooved, tiled and embossed.

3. Hardboard is also produced in a perforated type board with holes to hold special fixtures. This type board may also be used for acoustical purposes.

4. Decorative laminated core is manufactured to provide a core for high pressure decorative laminates.



Wood grain finishes come in a variety of colors, surfaces

1. Pecky teak
2. Wormy chestnut
3. Barnboard
4. Oak
5. Pecan
6. Rosewood
7. Ash
8. Cherry
9. Elm
10. English walnut

5. Laminated hardboard is made up with layers of hardboard laminated together to obtain greater strength and thickness.

6. Factory finished hardboard has a primer, decorative paint, or sealer applied before shipping to the consumer.

7. Molded hardboard products are being used extensively in the automobile industry. Examples of this application are door panels, arm rests, ceilings of station wagons and truck cabs, also head boards for Corvettes.

V. Particle Board

A. Particle board (in the family of composition board) is an engineered board, panel, or sheet that is made in many shapes and sized from wood particles. These particles are composed of small discreet pieces of wood bonded together in the presence of heat and pressure, with a synthetic resin adhesive or other suitable binder.

1. Particle board dates back to patents for its production, using animal glues, which were granted in the 1800's. During time was so long that this process never got into mass production.

2. In the late 1940's, small plants were started in the southern part of the United States, but it was 1951 before the first large plant was in operation in this country.

3. The two uses for particle board that are major in terms of volume, are furniture, such as cabinet core, and floor underlayment.

B. Manufacturing Process

1. Sources of raw materials

a) Commercial species of the low density hardwoods and softwoods may be used.

b) Shavings from lumber planing mills provide the most abundant and cheapest source of furnish. A furnish is the combination of chips, flakes, shavings, and splinters that go into the production of particle board.

c) Chips and splinters are produced by grinding cord wood in hammermills, or in chippers.

d) Flakes are particles produced on special cutting equipment to predetermined dimensions. A Pallmann flaker is used to perform this operation.

(1) The Pallmann flaker works on the principal of inertia and centrifugal force and produces an excellent furnish.

(2) Materials for the Pallmann flaker must be free from dirt and other foreign matter to prevent dulling of the knives

e) Multi-layered boards are particle boards with different types of particles on the surface and in the center of the board.

(1) The best known of these boards has a splinter or milled-flake center with thin-flake surfaces on the face and back.

(2) Another board is the Behr process which yields a three-layered, all-flake board, with thick center, and thin surface flakes.

2. Screening follows particle production. The output is usually screened to remove fines and particles that are too large.

a) The oversize particles are returned to the mill for reprocessing.

b) Screening is necessary to insure some uniformity in particle size.

3. Drying the flakes, shavings, and splinters takes place next in order to insure a dry mat, since all particle boards are dry formed.

a) If dry waste is used as a raw material, the drying operation may be omitted.

b) In general, usage in the United States is the rotary drum-type drier.

4. Mixing blinds the basic ingredients of wood particles and resin adhesive to prepare a furnish for the particle board mat. Sometimes other additives, such as wax aid the flow of the material and stops it from sticking in the press.

   a) There are two types of mixers, batch and continuous.

   b) The batch mixer is of simple design and operation. It is essentially a mixing chamber for resin and wood.

   c) Continuous mixing basicly provides for a continuous flow of the mixed product; whereas the batch mixer must have its materials weighed each time.

5. Particle boards are formed in one of two ways: by flat-pressing or by extrusion. These two methods are quite different, and the products produced have different properties.

   a) Flat-pressing is performed in a multiple-opening hot press.

      (1) The forming machine spreads an even, continuous mat of coated flakes on plates which are called cauls.

      (2) At this point, the first step of the "in plant" inspection is carried out by weighing each mat to see if it meets manufacturing specifications.

      (3) If the mats are rejected, they are returned to the blender where they are reused in future mats.

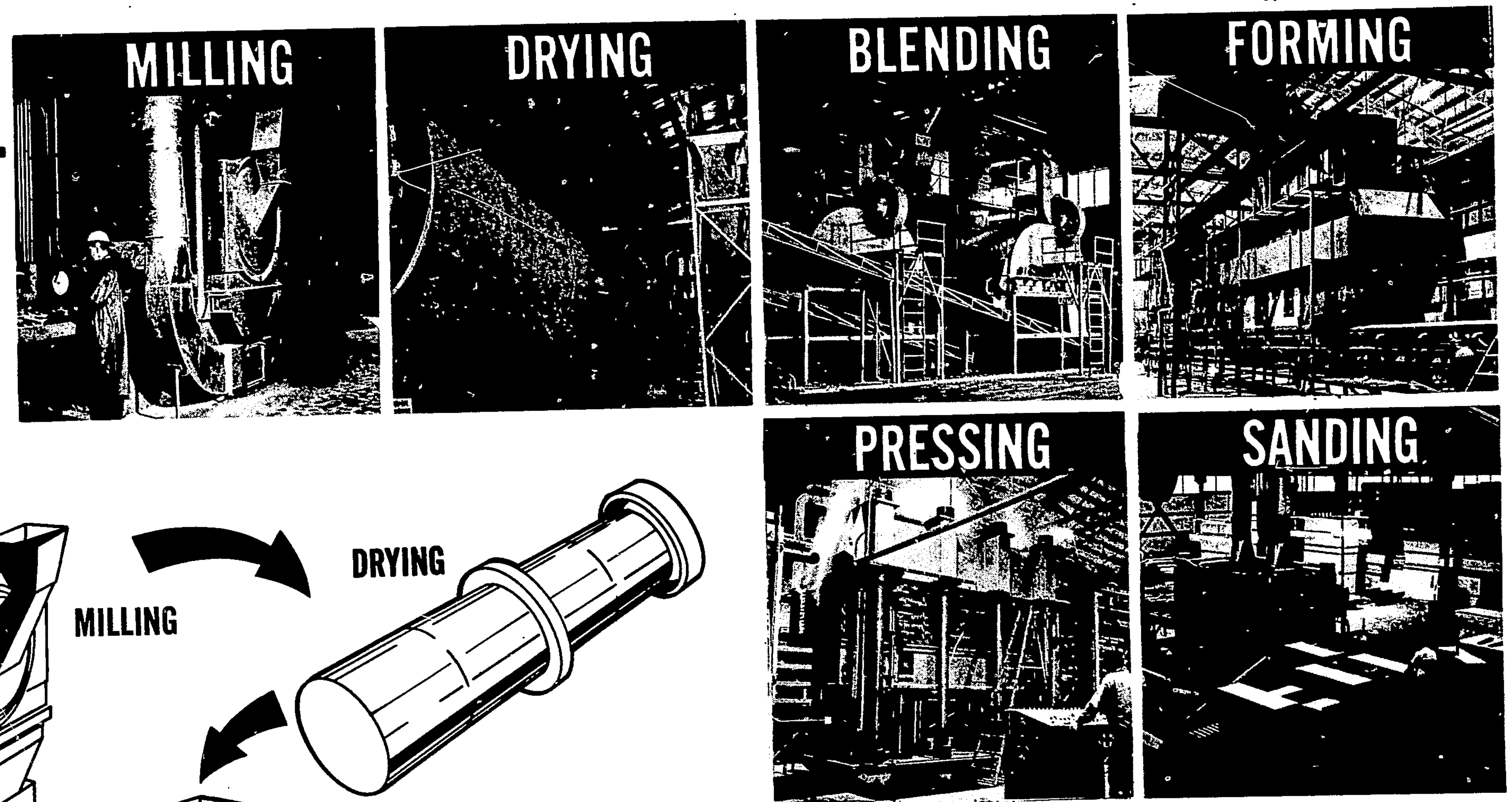
   b) Extrusion processes for making particle board is similar to the hot press method up to the blending operation.

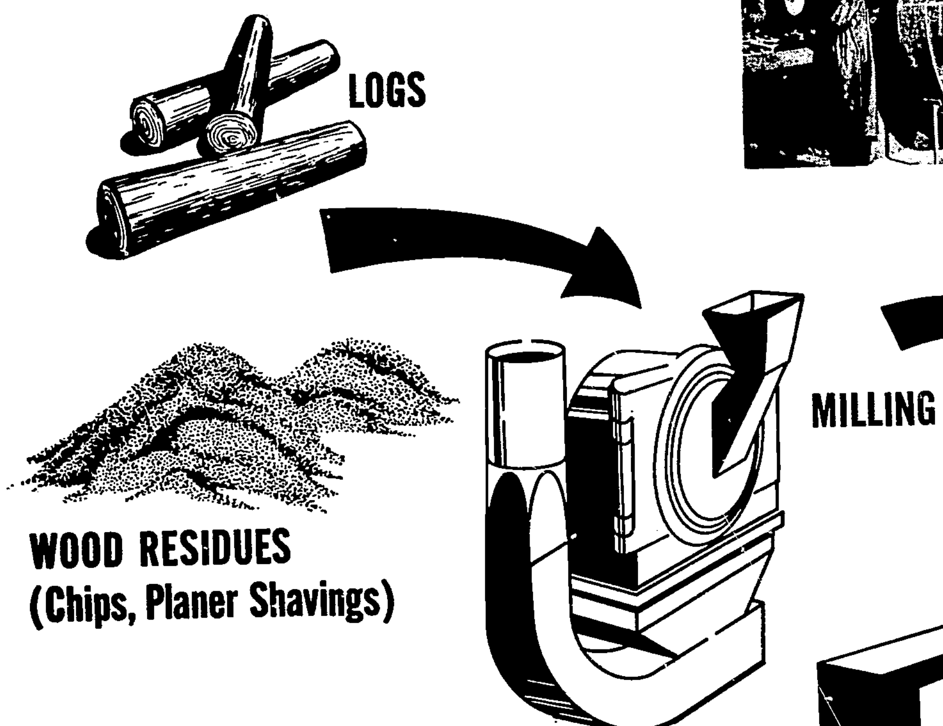
      (1) The blender feeds into an extruding machine which forces the coated fibers through a die.

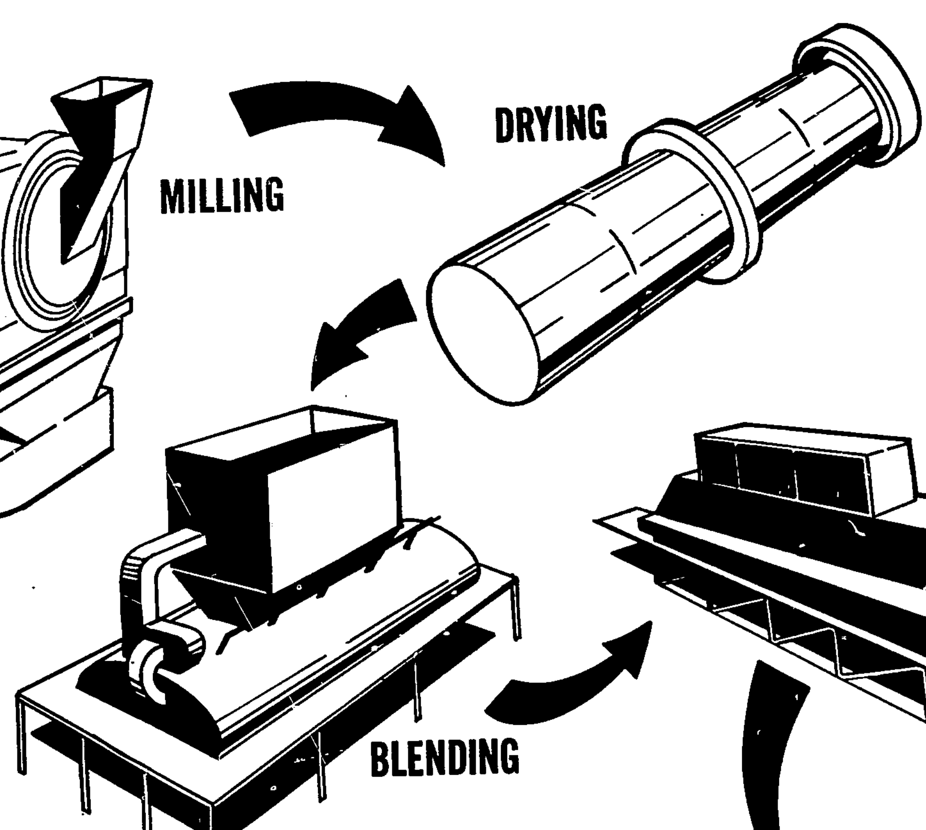
      (2) The die forms the sheet in width and thickness and the length is cut to specifications.

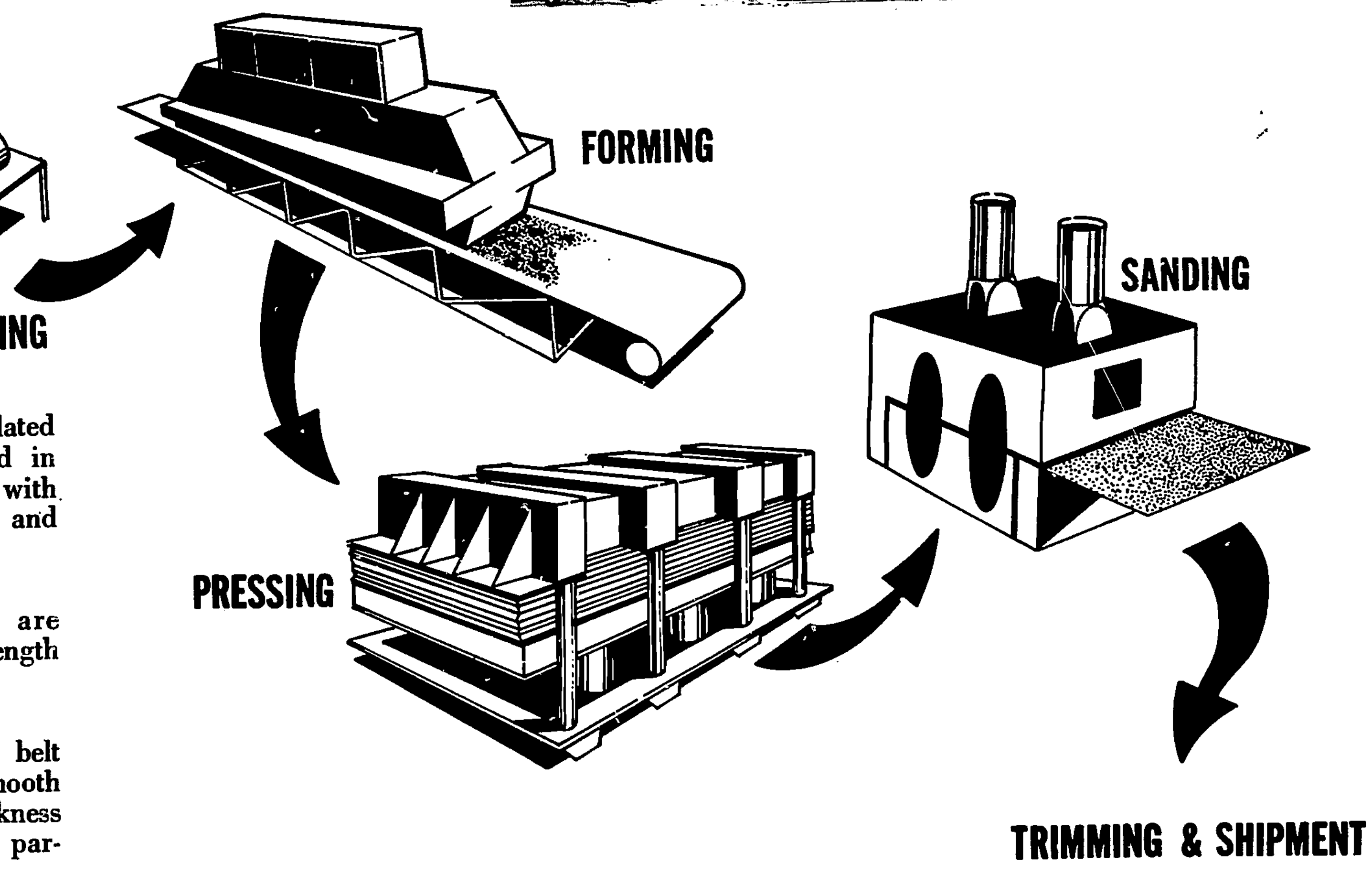
      (3) The sheets are cured within the machine by friction and come out ready for conditioning.

Production involves intricate processes..









1. Particleboard production begins with the raw materials—wood chips, planer shavings, or logs.

2. Flakers, hammermills, or other types of milling equipment produce the desired types of tiny wood particles.

3. Screens classify the particles into the proper mixture of sizes.

4. Dryers remove excess moisture and uniformly control the moisture content to the desired level.

5. Resin binders and other chemicals are sprayed onto the wood particles at a controlled rate in a blending operation.

6. Forming machines deposit the treated particles onto belts or metal cauls forming mats.

7. Particle mats are consolidated and the binders are cured in heated hydraulic presses with temperatures up to 400°F and pressures up to 1,000 p.s.i.

8. After pressing, boards are trimmed to the desired length and width.

9. Sanding in high speed belt sanders produces the smooth surfaces and accurate thickness tolerances characteristic of particleboards.

(4) Particles in this type of board tend to align so that the long dimension of the particle is randomly oriented in a plane perpendicular to the face of the board. Because of this difference in the physical properties in one direction, it is necessary to cross-band extruded panels with wood veneer to provide strength and stability. Most of this type board is used by furniture manufacturers.

(5) Trim saws. Trim the edges of the mats to press size and the waste is returned to the blender.

(6) The mat is automatically loaded into the hot press, which will hold up to twenty mats at one time. The time, temperature, and pressure used varies in accordance with the thickness and grade of particle board being produced.

(7) The board is consolidated under heat and pressure in the press to form particle board.

(8) Cauls and mats are removed from the press and coaled.

(9) Automatic feeders and stackers prepare the panels for the sizing saws.

(10) Continuous belt sanders, operating at a speed of about 150 feet per minute, sand both sides of the panels to very close telerances. (.005)

(11) The particle boards are now stored where they are conditioned before final shipment.

C. Types, Grades, and Sizes.

1. To select and specify the right type and grade of particle board panel for a specific job, it is important to know what is meant by an "engineered panel."

   a) There are certain variables that can be controlled during the manufacturing process to achieve a given end result. These variables include density, flake or particle configuration, amount and type of resin and moisture content.

(1) Density - Stock panels available today range in density from 24 to 62 pounds per cubic foot. Other things being equal, an increase in density of a given product will increase the strength properties proportionately.

(2) Particle Geometry - The size and shape of individual flakes and particles and the ratio of resins particles greatly influences properties of the board.

(3) Resin - Two types of resinm urea-formaldehyde and phenol-formaldehyde are used in the manufacture of particle board. Urea is for interior and phenol for exterior use.

(4) Moisture Content - Particle board used core material for overlay should have a moisture content of 7 to 9 per cent unless otherwise specified.

(5) Special Properties - Panels can be given special finishes or treatments for specific end uses. They may be filled or primed, embossed, edge-banded, cut to size, or given special sanding treatment.

b) Table 1 shows the minimum properties met by NPA manufacturers.

2. Sizes of particle board can virtually be any dimension by cutting or gluing segments together.

a) The standard thickness of panels will range from 1/8 to 2 inches.

b) The standard widths will run 3 to 8 feet.

c) The length will run up to 24 feet.

Table 12-1. Comparison of Types of Composition Boards

Board type	Process	Final board density	Basic Wood element	Type of binder	Board Thickness
Insulation board	Wet	Low: 10-26 lb per cu. ft.	Coarse, non-chemical fiber	Natural or none	½-1 in.
Hardboard	Wet Semiwet Dry	High: 50-80 lb per cu. ft.	Coarse, non-chemical fiber	Natural or adhesive	1/10-¼ in.
Particle board	Dry	Medium: 25-50 lb per cu. ft.	Small piece of whole wood	Adhesive	3/8-1½ in.

Table 12-2. Source of Raw Materials for Composition-board Plants[a]

Principal raw material	Number of plants		
	Insulation board	Hard-board	Particle board
Pulpwood.........................	13	11	9
Sawmill or plywood-mill residues....	4	8	21
Furniture or millwork manufacturing residues.........................	..	..	22
Waste paper......................	2		
Bagasse.........................	2		
Mixed or unknown raw material.......	2	2	11
Total plants reported.............	23	21	63

[a]Source: Technical Committee, Forest Products Research Society, Wood Composition Board Division. 1958 Status of the Composition Board Industry. Forest Prod. Jour., 9 (2): 53-56. 1959.

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VI. Sheetboard

Sheetboard is a sheathing product made from lower grades of lumber to which is glued kraft paper.

Sheetboard combines the insulation advantages of lumber with the conveniences of larger panels.

A. Manufacturing Process

1. Sheetboard is laid edge to edge for panel wide stability.

2. Sheathing grade lumber is used in this construction.

3. Wet strength kraft paper is applied to both sides of the panel wide sheet which gives it dimensional stability.

4. Water resistant glue is used in this construction.

5. Sheetboard is laid out in sheet size which makes it strong and rigid.

6. All boards which do not extend the full length of the panels are end matched and glued or finger-jointed and glued.

7. All wane in the boards is confined to one side of the panel.

B. Types

1. Sheetboard

   a) Sheetboard is used for subflooring and wall sheathing construction.

   b) Sheetboard is also used for cheaper grade furniture.

      (1) Size 2/4" x 4' x 8'

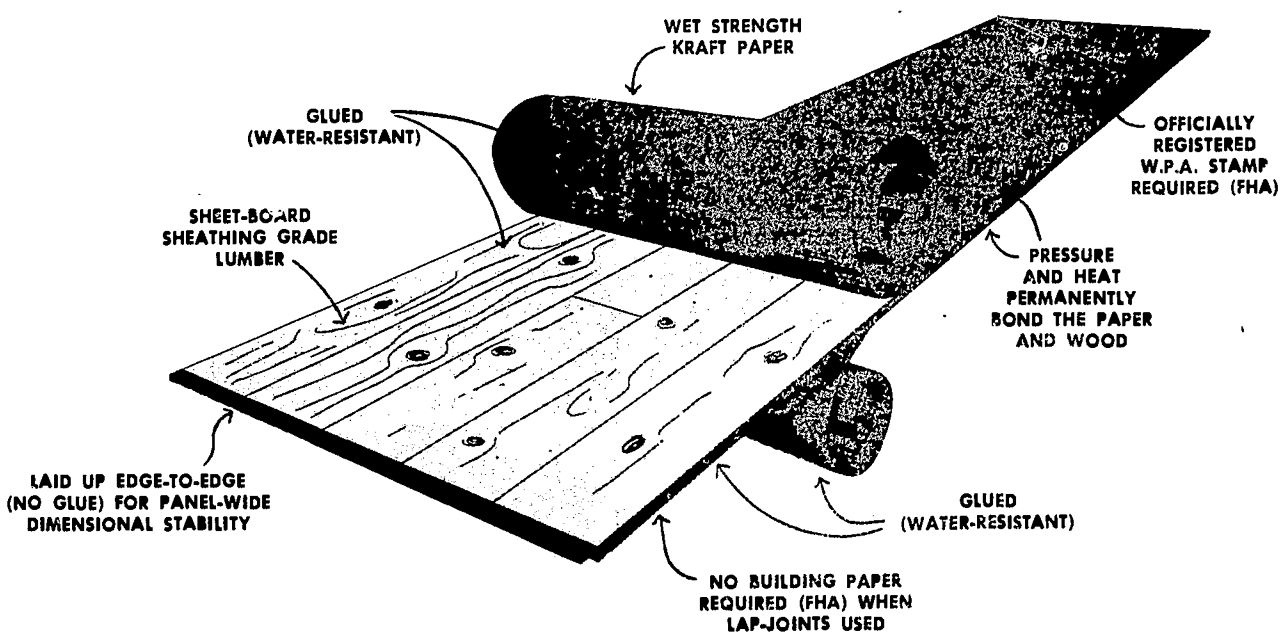
2. Sheet deck

   a) Sheet deck consists of two inch nominal thickness.

b) Sheet deck is used for flooring and roof decking.

(1) Size 2" x 4" and the length can be determined by the installation which permits a definite length.

The construction of sheetboard.



VII. Insulation Board

Insulation board is designed to minimize noise and to serve as a thermal barrier. It is manufactured from fibers of wood, cane or other vegetable matter and is applied to various areas in homes and commercial buildings.

A. Manufacturing Process

1. Insulation boards are made primarily from wood or cane fibers.

2. The raw materials are reduced to a pulp.

3. The fibers are chemically treated and water proofed and are formed into a felting process, dried and cut to the finished size board.

4. Many tiny air cells develop between the fibers during the felting process which gives it the insulation property.

5. Some insulation board is impregnated with asphalt to make it moisture resistant for definite uses.

B. Types

1. Building Board

a) Grade

(1) They are general purpose insulation board.

(2) These boards are used on interior finish for walls and ceiling.

(3) Some boards have a factory finished surface that requires no other decorations.

(4) Some boards have a base that requires finishes.

(5) Building board has square edges

b) Sizes

(1) Thickness 1/2"

(2) Width 4'

(3) Lengths 8', 9', 10', or 12'

2. Roof Insulation Board

a) Grade

(1) Roof insulation board provides permanent and efficient insulation for roof decks.

(2) The finished board may be either single or multiple piles joined by stapling, stitching or cementing.

(3) The edges are square for boards 1/2" in thickness.

(4) Thickness greater than 1/2" the edges are either square or offset. (shiplapped)

b) Sizes

(1) The sizes in thickness vary from 1/2" to 3" by 1/2" increments. 23" x 47", 24" x 48".

3. Sheathing Board

a) Grade

(1) Sheathing insulation board is a structural insulating board to use for wall sheathing.

(2) Sheathing boards are used for all types of wood frame construction.

(3) Sheathing boards are water resistant.

b) Sizes

(1) Thicknesses are 1/2", 25/32".

(2) Width 4'

(3) Length 8', 9', 10', or 12'.

VIII. Structural Sandwich Construction

Structural sandwich construction is a balanced layered panel formed by bonding two thin surface layers to a thick core. Sandwich board is an economical substitute used for wood in a variety of structural assemblies.

A. Materials Used in Structural Sandwich Construction

1. Facing Materials Used

   a) Wood products - plywood, single veneers or plywood overlaid with a resin-treated paper and hardboard are commonly used.

   b) Metal products - such as aluminum, enameled steel, stainless steel or magnesium sheet are also used.

   c) Miscellaneous products - include fiber-reinforced plastics or laminates and veneer bonded to metal.

2. Core Materials Used

   a) Lightweight materials such as balsa wood, rubber or plastic foams, and formed sheets of cloth, metal, or paper, have been used as core for sandwich construction.

   b) The presence of resin in the paper core is necessary to yield a product that is permanently strong and stiff in wet conditions.

B. Manufacturing Process

1. The principle operation is the bonding of the face sheets to the core, usually using the hot-press type equipment.

2. Roller presses or bagmolding equipment are also suitable for bonding face material to core stock and are used in some plants.

C. Applications of Sandwich Board

1. An important facing can be employed on sandwich board to act as a moisture barrier for a wall or roof panel in a house.

2. An abrasion-resistant facing can be used for facing of a floor panel.

3. Decorative effects can be obtained by using sandwich panels with plywood or plastic facing for walls, doors, tables, and other furnishings.

D. Advantages of Sandwich Board

1. Sandwich board provides a structural member of high strength and stiffness in proportion to its weight.

2. Sandwich construction is economical, since only small amounts of relatively expensive facing is used and the core material is usually inexpensive.

3. Core materials can be chosen to provide thermal insulation, fire resistance, and decay resistant properties.

E. Disadvantages of Sandwich Board

1. Special hardware such as plumbing and electrical wiring must be installed as the panel is being produced.

2. Edge inserts and connectors are needed for most general panel usages.

IX. Shingles

A shingle is a small thin piece of wood with parallel grain and edges which are thinner at one end than at the other. Shingles are commonly used as a building material for roofing and siding.

A. Woods used for shingles

1. Ninety per cent of all commercial shingles produced in the United States are from Western Red Cedar.

2. Southern Pine, Sugar Pine, Yellow Pine, Spruce, and Hemlock are also used but only in localized areas.

B. Manufacturing Techniques

1. Logs for shingle production are cut in standard lengths established by the mills.

2. They are then cut into 16", 18", or 24" lengths depending on the size of shingles to be produced.

3. These short bolts are then split or cut into quarters for ease in handling and to prepare them for the shingle machines.

4. The shingle machine may use a sawing or a splitting technique.

5. Both types use the technique of tilting the table at the end of each stroke to better utilize the material available and to produce less waste.

6. Following the cutting, each shingle is edged and graded.

7. The cut shingle is then bundled and kiln dried.

C. Classification of Shingles

1. The length of standard shingles are 16", 18", and 24".

2. Random widths are the most common form and they range from 3" to 14".

3. Thickness is measured at the butt when the material is green and this number is given in the number of butts needed to make a 2" thickness.

D. Grades of Shingles

1. No. 1 Shingle must be 100% clear, have 100% straight grain, and 100% heartwood which is used on primary buildings.

2. No. 2 Shingle must be clear and free of blemishes for 3/4 of the measured length and less than 10% sapwood in the first 10" of the length.

3. No. 3 Shingle must contain 8" of clear wood or better and may contain up to 30% sapwood.

E. Unit of Measure

1. The marketed bundle of shingle is called a square.

2. A square is theoretically the amount of shingles needed to cover 100 square feet of surface area.

F. Preservative Treatments

1. The pressure treatment is by far the most effective method, but the hot and cold dipping is also used.

2. Decolorized Creosote, pentachlorephenol, and copper naphthanate are being used frequently.

G. Desired Qualities of Wood Shingles

1. Wood shingles have a superior insulating quality.

2. The serviceable life of good shingles is at least twenty-five years.

3. The wood shingle is naturally resistant to all types of weather conditions.

4. Normally the appearance of wood shingles is considered to be attractive.

5. Wood shingles may be stained or painted if additional color is desired.

X. Pulp and Paper

The pulp and paper industry includes industries engaged in the production not only of paper but also of various types of board and other items made of wood pulp. Pulp is the crude fiber material produced from cellulosic raw material.

A. Pulp Manufacture

1. Pulpwood mills in the United States procure pulpwood from loggers as well as from pulpwood producers and farmers.

   a) Methods of delivering wood to the mill.

      (1) Water transportation, including driving, towing in booms, rafting, and delivery in barges and vessels.

      (2) Land transportation, including rail, truck, and sleigh.

   b) Condition of Delivered Pulpwood.

      (1) Pulpwood which is floated is usually delivered unbarked.

      (2) In the South, the pulpwood is frequently debarked by the pulpwood dealers.

   c) Storage of Pulpwood. The two major hazards of pulpwood storage are fire and decay.

d) Measuring of Pulpwood.

(1) By Volume

(a) The <u>cord</u> contains 128 cubic feet of space or 75 to 100 cubic feet of solid pulpwood.

(b) The <u>cunit</u> or <u>C-unit</u>, consisting of 100 cubic feet of solid, unbarked wood.

(c) The <u>board foot</u>. It is customary to consider 500 board feet as a cord of wood.

(2) By Weight

(a) A number of mills, particularly in the South, are buying pulpwood on the weight basis.

(b) Weight basis per cord is established at the mill by actually weighing a number of scaled logs.

e) Preparation and Treatment of Pulpwood.

(1) When pulpwood is delivered to the mill in log length, it is first reduced to shorter lengths in the breakdown mill.

(2) Before the blocks are reduced to chips all the bark must be removed. The machines for removing bark are called barkers, and the process of removing bark is referred to as rossing or debarking.

(a) In the woods during the active growing season bark is separated by the use of a long-handled chisel, called a spud, or with a draw-shave knife.

(b) Chemical debarking is also done in the woods by treating the tree at the base where part of the bark has been removed.

(c) Mechanical barkers at the mill are of two types.

(i) Those that are designed to separate bark by cleavage of the cambium layer.

(ii) Those removing the bark by the cutting action of knives.

(d) Hydraulic brakers at the mill employ water jets under pressure of up to 1,500 psi.

2. Mechanical pulp or groundwood pulp is produced by forcing round wood laterally against a revolving grindstone. By this means the wood is reduced to a fibrous mass, which, after screening and thinkening is converted into pulp products.

   a) Softwoods ground with a moisture content of 30 to 50 per cent including spruces, balsam fir, hemlocks, true firs, jack pine, and southern pine.

   b) Grinders are machines designed for reducing wood to mechanical pulp grinders.

      (1) Intermittent grinders which are hand or magazine fed.

      (2) Continuous grinders which increase production by cutting down on the time required for loading wood.

   c) Properties and Uses of Mechanical Pulp.

      (1) Contains practically all the wood substance, including lignin and hemicelluloses.

      (2) Pulp consists of bundles of fibers as well as fiber fragments, rather than the individual cell units.

      (3) Had a low initial strength.

      (4) Deteriorates rapidly in strength and turns yellow with age.

      (5) Low in brightness.

      (6) Has outstanding printing qualities.

3. Chemical pulping is accomplished by suitable chemical action which removes the more soluble cementing materials, largely lignin and hemicelluloses, leaving behind a fiberous mass (pulp), consisting of more or less pure cellulose.

   a) Sulfite Pulp.

(1) Woods Used - Slightly resinous to hardwoods.

(2) Liquor Preparation - The cooking liquor is a water solution of a bisulfite, containing an excess of sulfurous acid.

(3) Cooking - Cooking subjects the wood chips to the action of acid liquor at an elevated temperature and pressure long enough to produce pulp.

(4) Blowing and Digester - Cooking in all systems using a calcium base is continued until the sulfur dioxide content in the digester reaches the desired quality in the pulp. The contents are then forced into a large acid-resistant tank called the blow pit.

(5) Recovery of Gas - The efficiency of recovery of sulfur dioxide in the form of gas is very important from the standpoint of reduction in the consumption of sulfur per ton of pulp.

(6) Sulfite Spent Liquor Uses.

(a) Dust binders on unpaved roads.

(b) Ethyl alcohol and yeast production for stock feed.

(c) Molded plastics.

(d) Fertilization and soil-conditioning.

b) Alkaline Pulps.

(1) The Sulfate Process - given this name because sodium sulfide is obtained from sodium sulfate.

(a) Wood Used - Any kind, especially resinous woods.

(b) Cooking - Carried on in a welded-steel digester lined with fire brick.

(c) Washing - Determines the purity of pulp as well as completeness of chemical recovery.

(d) Recovery System

i) Burning of the concentrate

ii) conversion of sodium sulfide and sodium carbonate into caustic soda.

iii) Separation of impurities from the salts.

(e) By-Products of Sulfate Pulping

i) Tall oil used in the manufacture of soap.

ii) Sulfate turpentine used by the paint industry.

iii) Alkalin lignin is used in the negative plates of lead-acid storage batteries.

(2) Soda Process - Based on the principle that caustic soda dissolves lignin and hydrolyze and noncellulosic carbohydrate components of wood.

(a) Woods Used - Restricted practically to the hardwoods.

(b) Cooking - The stationary digesters used in the soda process are not lined with fire brick.

(c) Uses of Soda Pulp.

i) Manufacture of book and magazine stock.

ii) Manufacture of writing and absorbent papers.

4. Semi-Chemical Pulp - The standard commercial process of pulping wood generally results in yields of less than 50 per cent of the original wood by weight. In order to increase yields, a number of processes have been devised in which the wood chips are reduced to pulp by a mild chemical treatment, followed by mechanical refining of the softened chips to a fibrous mass.

5. Treatment of Pulp - Before either mechanical or chemical pulp can be converted into paper or shipped as such, it must undergo a series of treatments.

a) Screening - Screening is necessary to remove dirt, foreign matter, knots, and other uncooked or unbroken pieces of wood.

b) Thickening the Stock - The consistency of the stock is thickened to 3 to 6 per cent solids.

c) Bleaching - Pulp as it appears after screening and slushing is off-color, and is bleached to remove the off-color.

d) Alpha-cellulose Pulps - All grades of chemical pulp contain appreciable amounts of hemicelluloses and small quantities of lignin. These materials are removed by alkali treatment, generally with sodium hydroxide.

e) Lapping - If the pulp is not used immediately at the mill but prepared for shipment or storage, it is necessary to extract most of the water from the screened stock and make the pulp into sheets which can be placed in bundles or laps.

6. Old Paper - Paper stock, or wastepaper, is the second most important source of fiber in pulp and paper manufacture. The annual consumption of old paper ranges from 8 to 10 million tons, representing almost one-third of the total domestic wood-fiber requirement.

B. Paper Manufacture - Paper has been defined as matted or felted sheets of fibers, principally vegetable, formed on a wire screen from a water suspension. Paper derives its name from the wood Papyrus, a sheet originally made by pasting together thin sections of an Egyptian reed.

1. Beating - In this operation the fibrous material (pulp) suspended in water is given a mechanical treatment which results in cutting, splitting, and crushing the fibers.

2. Loading and Sizing - Various products are added to the stock in the beater to reduce the absorbent qualities of the pulp and to produce a smooth-finished paper surface.

a) Fillers

(1) Mineral substances including clay, talc, agalite, crown filler, and pearl filler.

(2) The fine particles of the filler occupy the spaces between the fibers, making the resulting paper smooth and opaque.

b) Sizing

(1) Papers are sized to make them less absorbent to ink and moisture.

(2) Accomplished by adding water-repellent material which coats the fibers and fills the spaces with a varnish-like substance.

3. Coloring

a) The natural color of paper produced from bleached pulp is yellowish.

b) White paper is produced by adding blue to neutralize the yellow.

c) Other shades are obtained by adding an appropriate dye or pigment to the pulp or as a coating to the paper surface.

4. Jordan - After the beating and refining operations, the pulp may go to a machine called the jordan, which further separates and frays the fibers and makes a more uniform mixture of all materials in the pulp.

5. Forming the Sheet - The process of making paper consists in interlacing the fibers and forming them into a continuous sheet.

a) The Fourdrinier Paper Machine.

(1) The Fourdrinier proper or wet-end is preceded by revolving screens where the paper is matted.

(2) Press Section

(a) The sheet still contains approximately 80 per cent water.

(b) Picked up by a woolen belt and carried through several smoothing presses

(c) The pressure exerted by the upper rollers squeezes out more water, presses down the roughness of the surface, and compacts the fibers.

(3) Drying

(a) After the pressing operation the sheet still contains 65 per cent water.

(b) The drying section consists of a series of about fifty smooth cast iron cylinders.

(c) The cylinders are arranged in pairs one above another, all rotating at the same speed, and are heated by steam passing through their hollow interiors.

(d) More water evaporates as the damp paper passes through the drying section.

(4) Calender - Calenders are smooth rollers giving a smooth finish to the paper.

b) The Cylinder Paper Machine - The essential feature of this machine is a cylindrical metal mold covered with a coarse bronze backing wire, over which is stretched a finer mesh wire on which the paper sheet is formed. It differs from the Fourdrinier type chiefly in the method by which a sheet of paper is formed.

c) Special Paper Machines.

(1) Harper Fourdrinier - Used for making lightweight papers, especially tissue, crepe, and cigarette papers. It differs from the standard Fourdrinier in that wet end of the machine is reversed end for end.

(2) Yankee Machine - Designed for making machine-glazed papers, with a glossy finish on one side only. It differs from the standard machines in the method of drying.

6. Selecting and Judging Paper

a) Classification of Paper Products

(1) Papers - Classified by the method produced or its use.

(a) Tissue - These are the lighest weight papers. Used for napkins, toilet papers, cigarette papers, and lightweight wrappings.

(b) Wrapping

i) Require great strength and pliability.

ii) Used for packaging or for the production of bags, envelopes, bread papers, and butchers' manila paper.

iii) Contain kraft or a good grade of sulfite pulps.

(c) Writing

i) Among these papers are the various kinds of stationery, typewriter sheets, and ledger and document papers.

ii) Usually made of rag or sulfite pulps.

(d) Printing

i) Newsprint, catalogues, rotogravure, and Bibles are characteristic uses.

ii) These papers vary a great deal in composition, ranging from a large proportion of groundwood pulp to pure rag content.

(e) Book

i) This special class of printing papers is used for the better books and magazines.

ii) The most important requirements are printability and attractive appearance.

iii) Sulfite and soda pulps are used.

(f) Building

i) Papers used in construction work are sometimes made of reclaimed paper mixed with asbestos.

ii) Included are sheathing paper to prevent wind penetration, felt papers for heat insulation, paper saturated with asphalt for waterproofing, and deadening felts for sound insulation of walls and floors.

(2) Boards - Papers thicker than 0.09 inch.

(a) Boards for containers

(b) Boards for building and insulating uses

XI. Wood Flour

Wood flour is basically wood that has been finely divided and screened to a desired particle size. The finest grinds resemble wheat flour; the coarser grades of this material, however, are distinctly fibrous. Wood flour was first produced commercially in 1906. Today 85% of the current total output is consumed as a filler in the formulation of explosives, linoleums, plastics, and other molded products.

A. Manufacturing Process

1. Raw Material

a) Today 75% of the wood flour produced in the United States is derived from three commercial soft pines: Eastern White, Western White and Sugar Pine.

b) The remaining 25% comes from the following: Spruce, Hemlock, Balsam Fir, Pond Pine, Aspen, Cottonwood, Beech, Birch and Maple.

c) When color is not important Willow, and Yellow Poplar can be used, and at times even Redwood.

2. Preparation of Wood

a) Wood flour is made by pulverizing clean, dry shavings and sawdust which has been dried to an 8-10% moisture content.

b) The sawdust and shavings are passed over a vibrating screen which separates the coarser materials from that which is of a size suitable for the pulverizing mill.

3. Pulverization Mills

a) Attrition Mill

(1) Double

(a) The double attrition mill consists of two metal grinding disks, revolving in opposite directions, enclosed in an iron housing.

(b) The solid lower disk is covered with grinding plates of hard steel provided with numerous "V" shaped depressions with sharp cutting edges.

(c) The upper disk is made up of spokes to which grinding plates, similar to those on the lower disk, are attached.

(d) Wood fed into the upper disk gradually finds its way through the spokes to the grinding surface, and the wood flour is forced out at the bottom of the enclosing case.

(2) Single

(a) Single attrition mills are equipped with a single revolving disk similar to the upper spoke disk of the double attrition mill.

(b) The wood material is pulverized by a rubbing action of this disk against the sides of the housing.

(c) Attrition mills are generally equipped with a pneumatic collecting system consisting of a manifold connected to the suction side of a fan which blows the flour to the sifting room.

b) Hammer Mill

(1) A hammer mill is composed of a horizontal, power-driven shaft fitted with a series of steel disks separated by spacers.

(2) Attached to each disk near its periphery are a number of free-swinging hammers.

(3) The hammer system is housed in a cylindrical metal chamber fitted at the top with a feed-in opening and with a screen of a prescribed mesh below.

(4) The interior wall of this cylinder contains the grinding surface.

(5) Screenings fed into this mill are pulverized by impact of the rapidly revolving hammers which throw the particles of wood against the grinding surface of the cylinder

c) Beater Mill

(1) The beater mill is a vertical, adaptation of the hammer mill. The hammers have been replaced by a number of free-swinging beater arms staggered along the vertically oriented drive shaft.

(2) When in motion, these arms whirl the screenings, which are let in at the top of the cylinder.

d) Roller Mill

(1) Single

(a) The single roller mill produces wood flour by passing the raw material between a moving roller and a stationary metal bedplate.

(b) Pulverization takes place at the line of contact between the roller and the bedplate.

(2) Double

(a) In the double roller mill wood flour is produced by passing the raw material between two or more pairs of steel rollers surfaced with teeth of varying degrees of fineness.

(b) Pulverization takes place as the wood particles pass vertically down through each pair of rollers to the collection system at the base.

4. Air Separators

a) Air separation is based on the principle, that for any given air velocity a point is reached at which the

air resistance of a particle of a given size is balanced by its weight.

b) The speed with which the air passes through the separator therefore, determines the fineness of the product.

c) Slow currents will only pick up fine dust while fast currents will carry larger particles. Therefore, by regulating the speed of air, the grade of the resulting product can also be regulated without the use of a screen.

d) The big advantage of an air separator is that even the finest flour collects in the enclosing cyclone dust collector with hardly any loss.

B. Types of Wood Flour

1. Technical Wood Flour

a) This material is manufactured under rigid quality standards and commands a high price.

b) Specific consumer requirements relate to its absorptive properties, resin content, weight, color and fineness.

c) Flour coarser than 60-mesh screenings and the mixing of several wood species is unacceptable.

d) Technical wood flour is used principally as a filler in resinoid plastics.

2. Nontechnical Wood Flour

a) The bulk of the wood flour currently produced in the United States is classified as non-technical wood flour.

b) It is manufactured to less rigid specifications than technical flour, and often consists of a mixture of both hardwood and softwood species.

c) Products utilizing non-technical wood flour are: linoleum, dynamite, moldings, artificial wood carvings and plastic wood.

3. Granularmetric Wood Flour

a) This product is a special grade of technical flour in which the wood particles must conform to a specific weight and size.

b) The product is difficult to produce within the tolerances allowed and hence is very expensive.

XII. Cellulose-derived products

Highly purified cellulose is used extensively as a basic material in the manufacture of a number of derived products such as rayon and acetate filaments and fabrics, transparent films, photographic films, artificial sponges, sausage casings, lacquers, plastics, and explosives. The two principal sources of cellulose suitable for the manufacture of these products are wood pulp and cotton linters.

A. Cellulose Filaments and Yarns. Cellulose filaments and yarns can be produced by the viscose, acetate, cuprammonium, or the nitrocellulose processes. In the past, the products of all four processes were collectively known in this country as rayon and sometimes as artificial silk.

1. Viscose Rayon

a) Cellulose is treated with strong sodium hydroxide solution forming an alkali cellulose. This is treated with carbon disulfide to form an alkali-soluble cellulose xanthate which in itself is an intermediate product.

b) Quite stable in organic solvents but disintegrates completely in hot dilute and cold concentrated acids.

c) Industrial uses include tire cord; conveyer and V-belts; abrasive, polishing, and sanding wheels; safety belts; and reinforcement for paper and plastics.

2. Acetate Rayon

a) Cellulose is treated with acetic anhydride, acetic acid, and a catalyst.

b) Differs from the cuprammonium and viscose rayons in that it is not a regenerated cellulose but a cellulose derivation and has distinct physical and chemical properties different from the original cellulose.

c) Unaffected by dilute solutions of acids and alkalies, but are decomposed by strong acids.

d) Industrial uses include tire cord; conveyer and V-belts; abrasive, polishing, and sanding wheels; safety belts; and reinforcement for paper and plastics.

e) Special forms are used in lightweight raincoats, strong coated fabrics, and typewriter ribbons.

3. Cuprammonium Rayon

a) Cullulose is treated with basic copper sulfate and ammonium tartrate.

b) Quite stable in organic solvents but disintegrate completely in hot dilute and cold concentrated acids.

c) Used in textiles and mixed with other fibers.

4. Nitrocellulose Rayon

a) Cellulose is dissolved in nitric acid and sulfuric acid.

b) Used in the electrical field because of its low conductivity, dimensional stability, and flexibility.

5. Staple Fiber. Staple fiber is made by cutting rayon and acetate yarns into short lengths and then spinning them into thread. The thread is used in various textiles.

B. Transparent Cellulose Films. Transparent cellulose films are produced from viscose, cellulose acetate, ethyl cellulose, and nitrocellulose.

1. Cellophane

a) The manufacture of cellophane is identical to yarn manufacture, except that cellulose-containing solutions are forced through long slits instead of spinnerets.

b) Cellophane is quite permeable to water vapor.

c) Some grades are treated with a thin film of cellulose nitrate lacquer to make it resistant to the passage of water vapor.

d) Cellophane films can be dyed any desired color or embossed by means of pressure rolls.

2. Cellulose Acetate Films

   a) These films are cast through a narrow slot on the polished surface of a metal drum, which rotates in a drying chamber.

   b) More water resistant than cellophane.

   c) They have good electrical resistance, and not embrittled when exposed to sunlight.

   d) Self-sealing under heat and pressure.

   e) Permeable to gases.

   f) Uses.

      (1) Overwrapping fruits and vegetables and other products which require gas permeability to permit ripening and to prevent premature rotting and molding.

      (2) The largest outlet for acetate films outside of packaging is in the manufacture of photographic and X-ray films and sound and visual recording tapes.

3. Nitrocellulose Films.

   a) Made from cellulose nitrate.

   b) Produced by treating cotton linters and shredded wood pulp with nitric and sulfuric acids in the presence of water.

   c) Used in making commercial motion-picture films, but is highly inflammable.

4. Ethyl Cellulose Films.

   a) Made from an alkali cellulose.

   b) These films are flexible at low temperatures, have good water-resistance and excellent electrical-resistance properties.

   c) Self-sealing under heat and pressure.

d) Uses.

(1) Packaging

(2) Electrical insulation

C. Cellulose Sponges.

1. In the manufacture of cellulose sponges, a viscose solution is mixed with long-fibered vegetable hair and crystals of salt, insoluble in the cold viscose.

2. The batch is poured into molding cans and heated causing the crystals to dissolve, leaving holes.

3. The sponges are washed, dried, and cut to the desired sizes.

D. Explosives.

Nitrocellulose is used as a stabilizing agent in blasting gelatins and as a major explosive ingredient in smokeless powders.

E. Lacquer.

1. The first and most important cellulose derivative used in lacquers is cellulose nitrate.

2. Lacquers are made by mixing cellulose nitrate with resins, plasticizers, and organic solvents.

3. More recently lacquers have been made with mixed cellulose esters and with ethyl cellulose.

4. Has a high resistance to:

a) Heat

b) Light

c) Water

d) Low inflammability

F. Cellulose Plastics. Numerous molding and extrusion powders are made with cellulose derivatives, for the manufacture of a great variety of plastics.

BIBLIOGRAPHY
RELATIVE TO
LUMBER GRADES AND SIZES

Grading Booklets

National Hardwood Lumber Association. Rules for the Measurement and Inspection of Hardwood Lumber and Cypress.

Southern Pine Inspection Bureau. Standard Grading Rules for Southern Pine Lumber.

National Hardwood Lumber Association. An Introduction to the Grading and Measurement of Hardwood Lumber.

Western Wood Products Association. Standard Grading Rules for Ponderosa Pine, Sugar Pine, Idaho White Pine, Logepole Pine, Western Larch, Douglas Fir, White Fir, Engelmann Spruce, Incense Cedar, Western Hemlock, Sitka Spruce, and Western Red Cedar Lumber.

West Coast Lumber Inspection Bureau. Standard Grading and Dressing Rules for Douglas Fir, Sitka Spruce, West Coast Hemlock and Western Red Cedar. No. 15. Effective 3-15-56.

Redwood Inspection Service. Standard Specifications for Grades of California Redwood Lumber.

Northern Hardwood and Pine Manufacturers Association. Official Grading Rules for Northern White Pine, Norway Pine, Jack Pine, Eastern Spruce and Northern White Fir.

Northern Hardwood and Pine Manufacturers Association. Official Grading Rules for Eastern Hemlock Lumber.

Northern Hardwood and Pine Manufacturers Association. Official Grading Rules for Northern Hardwood and Softwood Logs and Tie Cuts.

Northern Hardwood and Pine Manufacturers Association. Lumber Grade Use Guides (Eastern Hemlock, Tamarack and Northern White Cedar).

Northern Hardwood and Pine Manufacturers Association. Hardwood Lumber and Timber for Buildings and Other Structures.

Northern Hardwood and Pine Manufacturers Association. Northern White Pine, Norway Pine and Eastern Spruce.

Northeastern Lumber Manufacturers Association, Inc. Standard Grading Rules for Eastern Spruce and Balsam Fir.

Northeastern Lumber Manufacturers Association, Inc. Standard Grading Rules for Northern White Pine and Norway Pine.

Northeastern Lumber Manufacturers Association, Inc. Official Grading Rules for Eastern Hemlock.

Southern Cypress Manufacturers Association, Standard Specifications for Grades of Tidewater Red Cypress.

Selected Textbooks

Brown, Nelson C. and Bethel, James S. Lumber. John Wiley & Sons, Inc., 1958. pp. 241-268.

Feirer, John L. Cabinet Making and Millwork. Chas. A. Bennett Co., Inc., 1967. pp. 177-181.

Feirer, John L. Woodworking for Industry. Chas A Bennett Co., Inc., 1963. pp. 111-117 and 122-123 and 486-487.

Dahl, Alf and Wilson, J. Douglas. Cabinet Making and Millwork, Tools, Materials, Construction, and Layout. American Technical Society, 1956. pp. 176-182.

Wagner, Willis H. Modern Woodworking. Goodheart-Wilcox Company, Inc., 1967. pp. 2-2 to 2-4.

Forest Products Laboratory, Wood Handbook. U.S. Department of Agriculture, 1956. Agriculture Handbook #72. pp. 105 to 137.

Periodicals

Smith, A. T. "Lumber Standard in Transition" Materials Research and Standards. April, 1966 Vol. 6, pp. 194-197.

Popular Mechanics. "Why is it Called a 2 x 4"? May, 1967. pp. 127-177.

Engineering New-Record. "Lumber Ballot Called Misleading", Nov. 26, 1965, Vol. 175, pp. 18.

Engineering News-Record. "Lumbermen Offer New Standard", May 13, 1965, Vol. 174, pp. 28.

Consumer Report. "Whittling Away at Lumber Size Standards", January, 1966, Vol. 31, pp. 5-6.

Mikesell, A. "They May Trim the 2 x 4 Some More; proposed New Size Standards for Softwood Lumber", Popular Mechanics, January, 1964, Vol. 121, pp. 113-115.

Engineering News-Record. "Pressure Is On For Lumber Standard", May 13, 1965, Vol. 174, pp. 28.

Engineering News-Record, "Commerce Rejects Softwood Revision", August 6, 1964, Vol. 173, pp. 62.

Engineering News-Record. "Lighter Lumber? Straw in the Wind Signals Cut in Softwood Dimensions" Feb. 7, 1963, Vol. 170, pp. 24.

Hand, J., "How to Buy the Right Board for the Job", American Home, Sept. 1961, Vol. 64, pp. 83-84.

BIBLIOGRAPHY

RELATIVE TO VENEER

Coleman, Donald G. Woodworking Factbook. New York: Robert Speller and Sons, 1966.

Freirer, John L. Woodworking for Industry. Peoria, Illinois: Charles A. Bennett Co. Inc., 1963.

Groneman, Chris H. and Glazener, Everett R. Technical Woodworking. New York: McGraw-Hill Book Company, 1966.

Groneman, Chris H. General Woodworking. New York: McGraw-Hill Book Company, 1959.

Holtrop, William F. and Hjorth, Herman, Principles of Woodworking. Milwaukee: The Bruce Publishing Company, 1961.

Panshin, A. J., E. S. Harrar, J. S. Bethel, and W. J. Baker. Forest Products. New York: McGraw-Hill Book Company, 1962.

PAMPHLETS

Plywood Facts and Information Packet, American Plywood Association, Tacoma, Washington.

BIBLIOGRAPHY

RELATIVE TO PLYWOOD

Coleman, Donald G. Woodworking Factbook. New York: Robert Speller and Sons, 1966.

Feirer, John L. Woodworking for Industry. Peoria, Illinois: Charles A. Bennett Co. Inc., 1963.

Groneman, Chris H. and Glazener, Everett R. Technical Woodworking. New York: McGraw-Hill Book Company, 1966.

Groneman, Chris H. General Woodworking. New York: McGraw-Hill Book Company, 1959.

Holtrop, William F. and Hjorth, Herman, Principles of Woodworking. Milwaukee: The Bruce Publishing Company, 1961.

Panshin, A. J., E. S. Harrar, J. S. Bethel, and W. J. Baker Forest Products. New York: McGraw-Hill Book Company, 1962.

Pamphlets.

Plywood Facts and Information Packet, American Plywood Association, Tacoma, Washington.

BIBLIOGRAPHY

RELATIVE TO FIBER BOARD

Feirer, John L., Woodworking for Industry. Charles A. Bennett Company, Inc., Peoria, Illinois: 1963 Unit #12.

Groneman, Chris H. and Glazener, Everett R., Technical Woodworking. New York: McGraw-Hill Book Company, 1966, Unit #10.

Lewis, Wayne C., Insulation Board, Hardboard, and Particleboard. Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Madison, Wisconsin: March 1967.

Reference Material

America Hardboard Association; 20 North Wacker Drive; Chicago, Illinois 60606: Booklets and Brochures available.

1. The Story of Hardboard
2. Hardboard - Commercial Standard CS251063
3. Hardboard Sales Guide
4. What Builders Should Know About Hardboard
5. Masonite Hardboards, for Home, Industry and Business

Movie, "Time for Change" Masonite Corporation, 29 North Wacker Drive, Chicago, Illinois: 60606.

Slides, Samples and Booklets
Kit may be obtained from American Hardboard Association for $5.00.

BIBLIOGRAPHY

RELATIVE TO PARTICLEBOARD

Brown, Nelson C. and Bethel, James S. Lumber. New York: John Wiley and Sons, Inc., 1965.

Feirer, John L. Industrial Arts Bench Woodwork. Peoria, Illinois: Chas. A. Bennett Co., 1965.

Feirer, John L. Industrial Arts Woodworking. Peoria, Illinois: Chas. A. Bennett Co., 1965.

Groneman, Chris H. General Woodworking. New York; McGraw-Hill Book Company, 1964.

Groneman, Chris H. and Glazener, Everett R. Technical Woodworking. New York: McGraw-Hill Book Company, 1966.

Hammond, James J., Donnelly, Edward T., Harrod, Walter F., and Rayner, Norman A. Woodworking Technology. Bloomington, Illinois: McKnight and McKnight Publishing Company, 1965.

Holtrop, William F. and Hjorth, Herman. Principles of Woodworking. Milwaukee, Wisconsin: The Bruce Publishing Company, 1961.

Panshin, A. J., Harrar, E.S., Bethel, J.S., and Baker W. J. Forest Products: Their Sources, Production, and Utilization. New York: McGraw-Hill Book Company, 1962.

Wagner, Willis H. Modern Woodworking. Homewood, Illinois: The Goodheart-Wilcox Company, Inc., 1967.

Wolansky, Wm D. Woodworking Fundamentals. New York: McGraw-Hill Book Company, 1962.

Particleboard Specification and Data File. Washington, D.C. 20005: National Particleboard Association, 1966.

Story of Particleboard. American Forest Products Industries, Inc. 1835 K Street, N.W., Washington, D.C. 20006.

Wood Handbook. Washington, D.C.: The Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, 1955.

BIBLIOGRAPHY

RELATIVE TO SHEETBOARD

John L. Feirer, Woodworking for Industry, Peoria, Illinois, Chas. A. Bennett Co., Inc.

International Conference of Building Officials, Western World Products Association. Yeon Building, Portland, Oregon.

BIBLIOGRAPHY

RELATIVE TO INSULATION BOARD

John L. Feirer, Woodworking for Industry, Peoria, Illinois, Chas. A. Bennett Co., Inc.

Insulation Board Institute, Fundamentals of Building Insulation, Chicago, Illinois.

BIBLIOGRAPHY

RELATIVE TO STRUCTURAL SANDWICH CONSTRUCTION

Wood Handbook #72. Washington, D.C.: The Forest Product Laboratory, Forest Service, U.S. Department of Agriculture, 1955.

BIBLIOGRAPHY

RELATIVE TO SHINGLES

Panshin, Harrar, and Bethel. Forest Products. New York: McGraw-Hill Book Company, Second Edition.

BIBLIOGRAPHY

RELATIVE TO PULP AND PAPER

Kohn, Max and Martin J. Starfield. Materials and Processes. New York: The MacMillian Company, 1952.

Panshin, A. J., E. S. Harrar, J. S. Bethel, and W. J Baker, Forest Products, 2d ed. New York: McGraw-Hill Book Company, Inc., 1962.

Movie "Paper in the Making." 25 min. color from Texas Forest Service, Texas A & M University, College Station, Texas.

BIBLIOGRAPHY

RELATIVE TO CELLULOSE DERIVITIVES

Moncrieff, R. W. Man-made Fibers, 3d ed. New York: John Wiley & Sons, 1957.

Ott, E. Cellulose and Cellulose Derivatives, 2d ed. New York: Interscience Publishers, Inc., 1954.

Panshin, A. J., E. S. Harrar, J. S. Bethel, and W. J. Baker. Forest Products, 2d ed. New York: McGraw-Hill Book Company, Inc., 1962.

BIBLIOGRAPHY

RELATIVE TO WOOD FLOUR

Reineke, L. H. Wood Flour. Wisconsin: Forest Products Laboratory, 1966.

VENEER CUTS

William H. Geiger

A very important phase of the plywood industry is the cutting of veneers. Each method of cutting produces its own distinct tone and grain pattern. The instructional aid shows the methods of cutting these veneers, and the grain pattern produced from each cut.

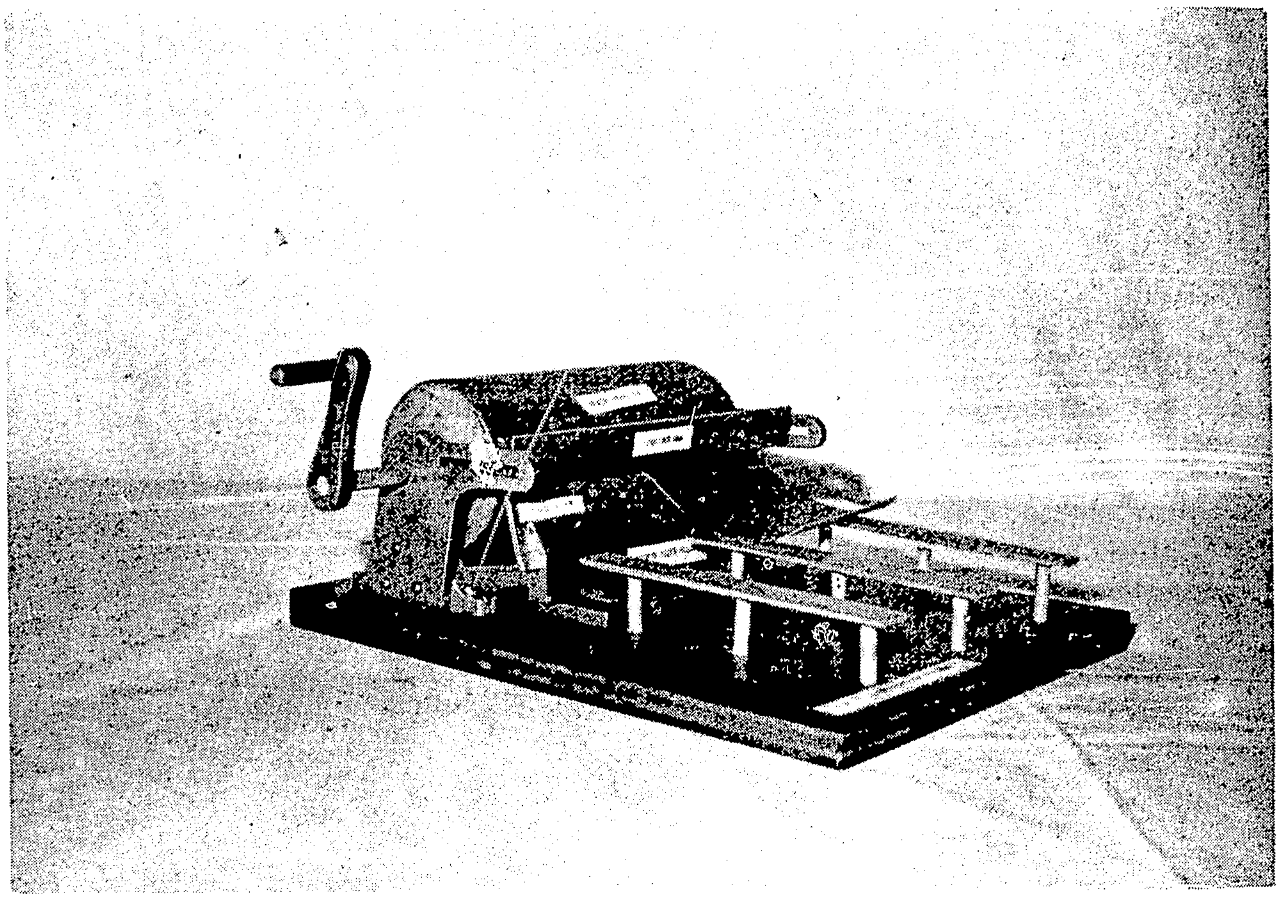
Objectives of Instructional Aid

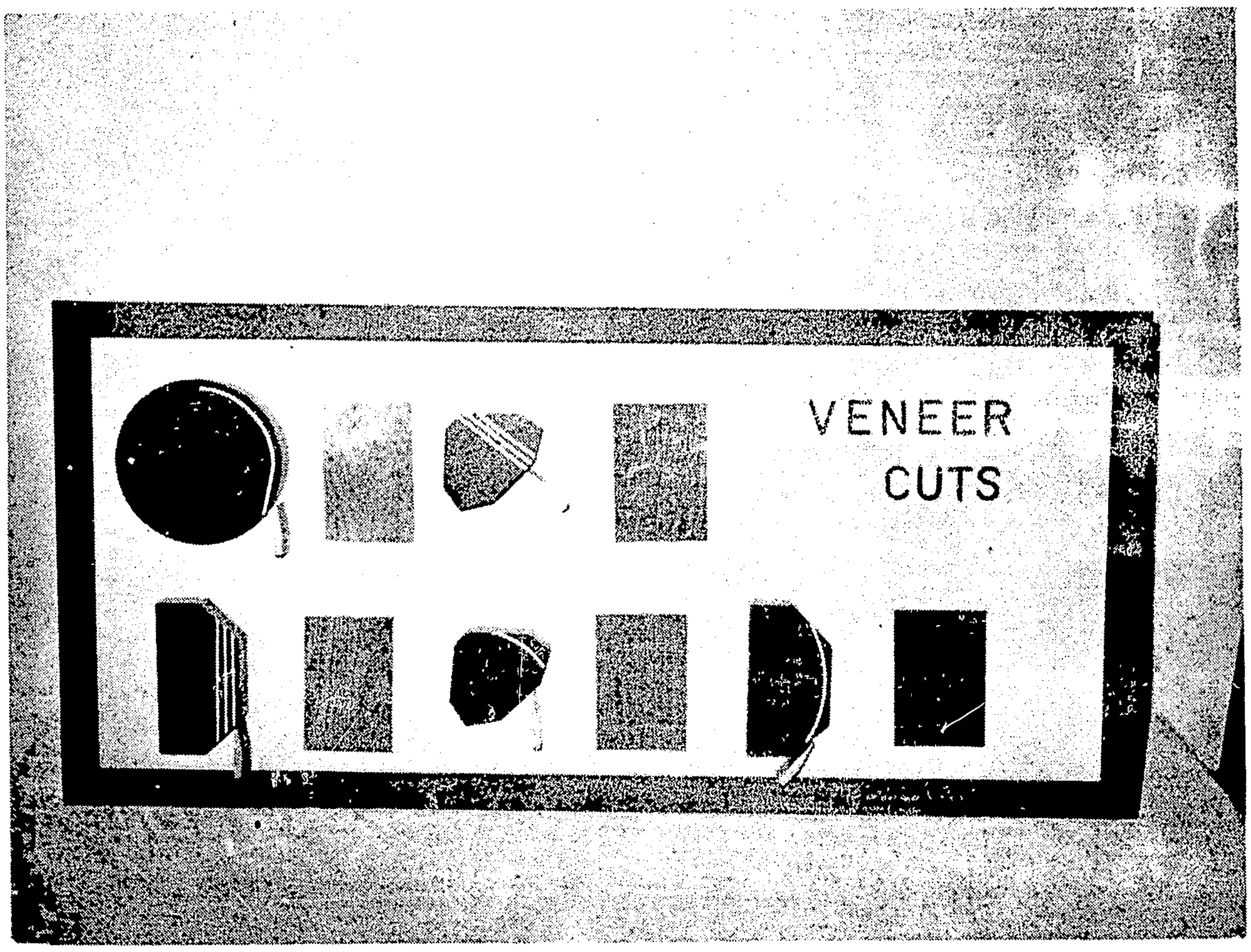
1. To familiarize the student with the plywood industry.
2. To show an industrial method of wood utilization.
3. To teach the student the five industrial methods of cutting veneers.
4. To familiarize the students with the technical terms used in the plywood industry as related to veneer cuts.

Technical Information

The five types of cuts represented on the instructional aid are:

1. Plain Sliced. From the trunk of the tree, take a half section and cut parallel to the diameter.
2. Quartered. When we take a pie-shaped wedge (quarter) of the tree, and cut across the growth rings at a perpendicular angle, we develop quartered veneer.
3. Rotary. When we revolve the whole log in a lathe against the knife, we develop rotary veneer.
4. Half Round. The log is first halved. The log section is then spun on the eccentric area which gives a cut halfway between a plain sliced and a rotary cut.
5. Rift Cut. The log is first cut into quarters and squared off. This cant is affixed to a stay log, and a quarter round rotary cut produces the type we know as rift cut.




VENEER
CUTS

ROTARY VENEER CUTTING LATHE MODEL

Wallace K. Hart

The purpose of this model is to present to the student the principle underlaying one of the methods of cutting veneer. This model depicts the method by which the largest percentage of veneer is produced.

Material and Equipment

Rotary cutting veneer model.
Samples of various types of veneer that are cut by this method.
Samples of veneer that are cuty by slicing and stay log methods.
Samples of various types of plywood.
Samples of the different methods of matching veneers.

Procedure

1. Define and show samples of veneer.

2. Illustrate with a small log, how wood is prepared for veneering (remove the bark on the regular wood lathe with a gouge).

3. Explain why a "peeler log" must be of high quality.

4. Point out each of the parts of the model.

    a. Centers that hold the log in position so that it may rotate.

    b. Veneer knife. This knife is fed against the rotating log so that the wood is sliced off similiar to the way a sheet of paper is unrolled from a roll.

    c. Pressure or nose bar. This bar is held against the log directly above the knife. The distance between the nose bar and the knife determines the thickness the veneer.

    d. Power arm. This arm is used to simulate the power that rotates the log against the blade.

e. Outfeed rack. This series of strips represent the ways that carry the veneer out to where it is cut into suitable size sheets for the making of plywood. Those pieces with defects such as holes, knots and splits are generally used for the core of plywood or may be cut into narrow pieces which are glued edge to edge and made up into sheets.

5. The sample pieces of veneer are used to illustrate how the various plys are laid up at right angles to form plywood.

Student Activities

1. The students may make a piece of plywood with sample veneers and test its strength as compared with a piece of solid wood of the same thickness.

2. The student may make a list of those items in their homes that have plywood used in them.

REFERENCES

Wagner, Willis H. Modern Woodworking. Homewood, Illinois: Goodheart-Wilcox Co., 1967. Sec. 25 pp. 11-14.

Feirer, John L. Woodworking for Industry. Peoria, Illinois: Chas. A. Bennett Co., Inc., 1963. Unit 11.

ROTARY

The log is mounted centrally in the lathe and turned against a razor sharp blade, like unwinding a roll of paper. Since this cut follows the log's annular growth rings a bold variegated grain marking is produced. Rotary cut veneer is exceptionally wide.

ALMOST ALL SOFTWOOD PLYWOOD IS CUT THIS WAY. LENGTHS IN ALMOST ALL HARDWOOD ARE LIMITED TO 8' - 0".

PLAIN SLICING (OR FLAT SLICING)

The half log, or flitch, is mounted with the heart side flat against the guide plate of the slicer and the slicing is done parallel to a line through the center of the log. This produces a variegated figure similar to that of plain sawn lumber.

QUARTER SLICING

The quarter log or flitch is mounted on the guide plate so that the growth rings of the log strike the knife at approximately right angles, producing a series of stripes, straight in some woods, varied in others.

HALF-ROUND SLICING

A variation of rotary cutting in which segments or flitches of the log are mounted off center in the lathe. This results in a cut slightly across the annular growth rings, and visually shows modified characteristics of both rotary and plain sliced veneers.

OFTEN USED ON RED OAK

BACK-CUT

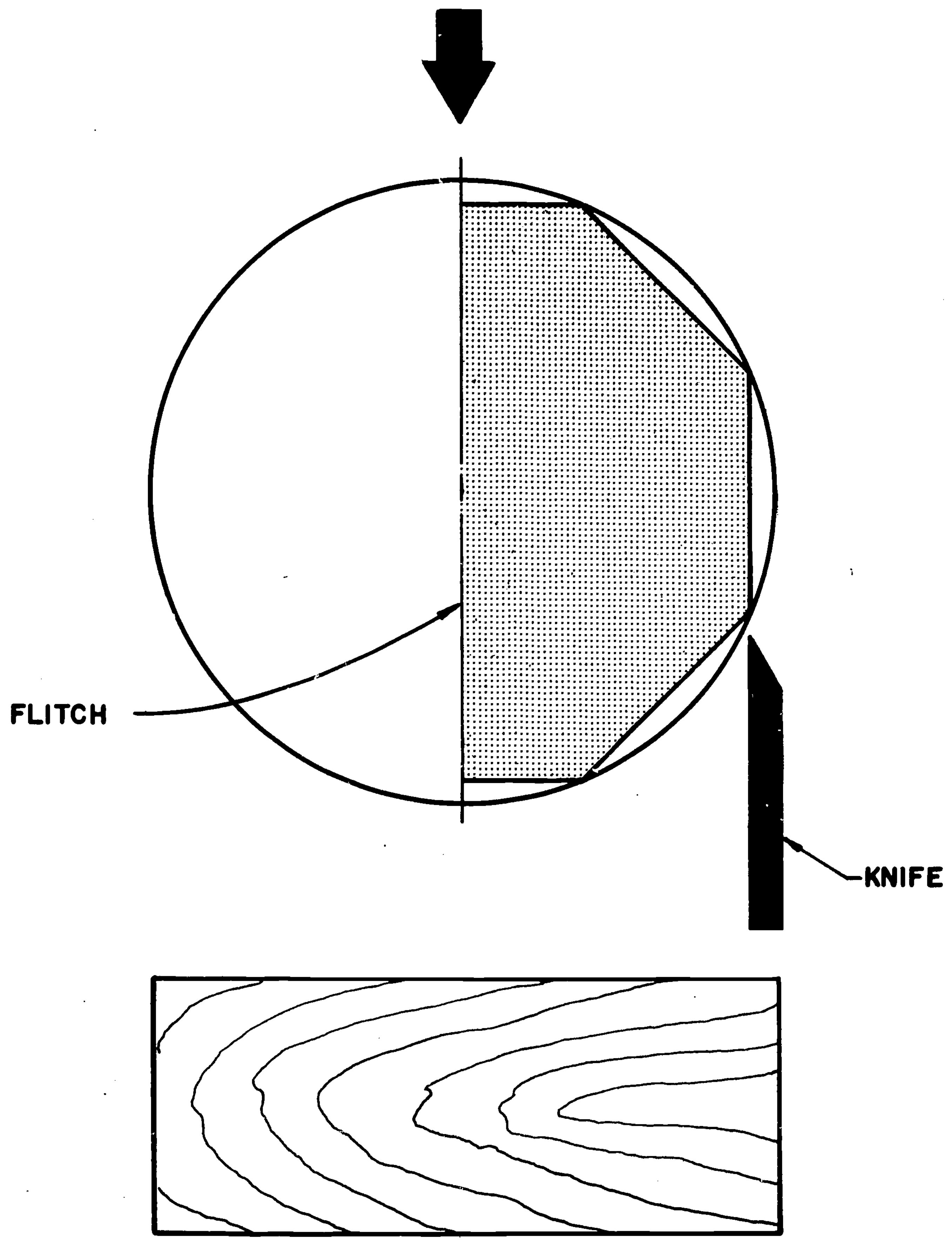
The flitch is mounted as in half-round cutting except that the bark side faces in towards the lathe center. The veneers so cut are characterized by an enhanced striped figure and the inclusion of sapwood along the edges.

LESS OFTEN USED

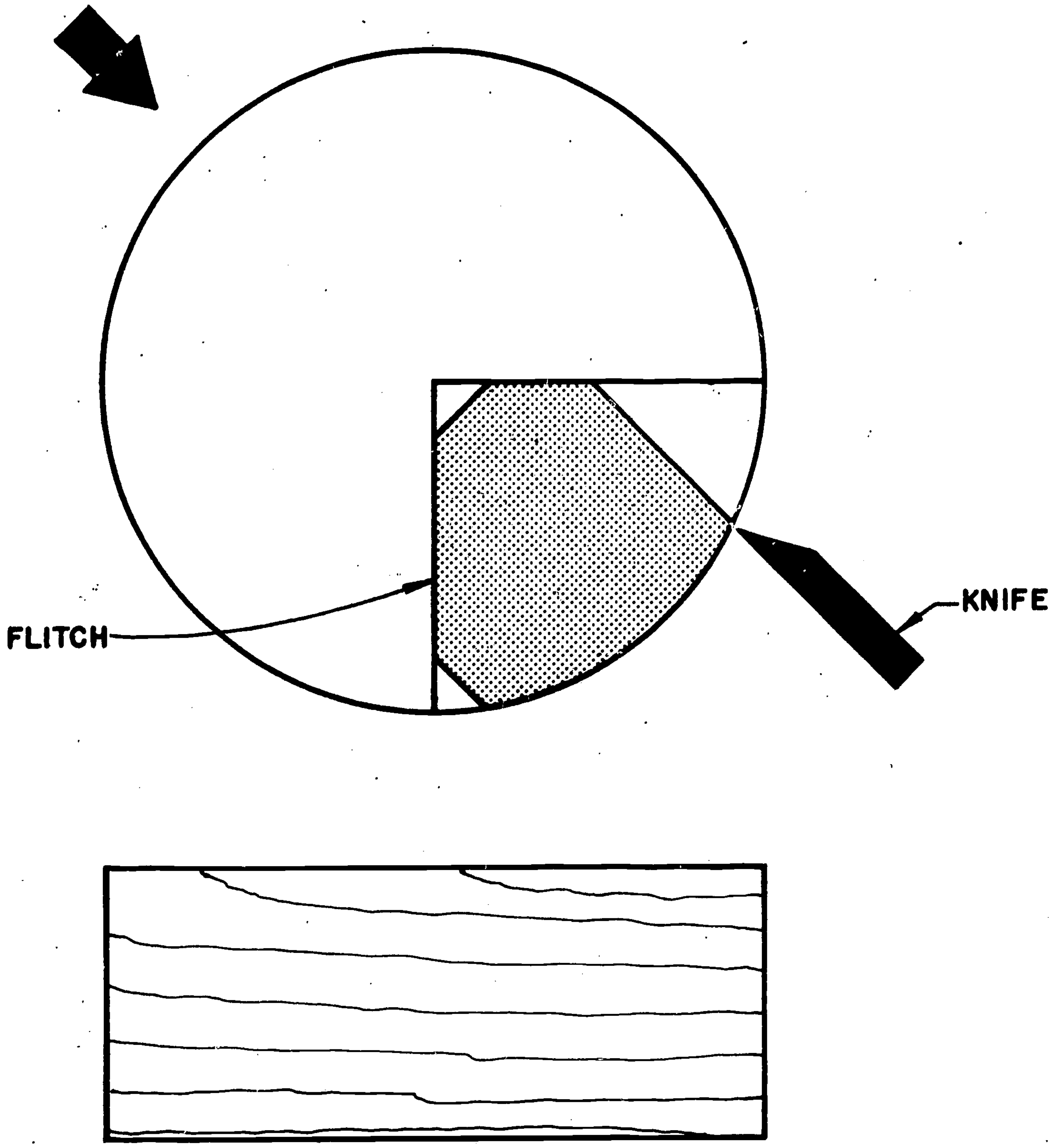
RIFT-CUT

Rift cut veneer is produced in the various species of Oak. Oak has medullary ray cells which radiate from the center of the log like the curved spokes of a wheel. The rift or comb grain effect is obtained by cutting slightly across these medullary rays either on the lathe or slicer.

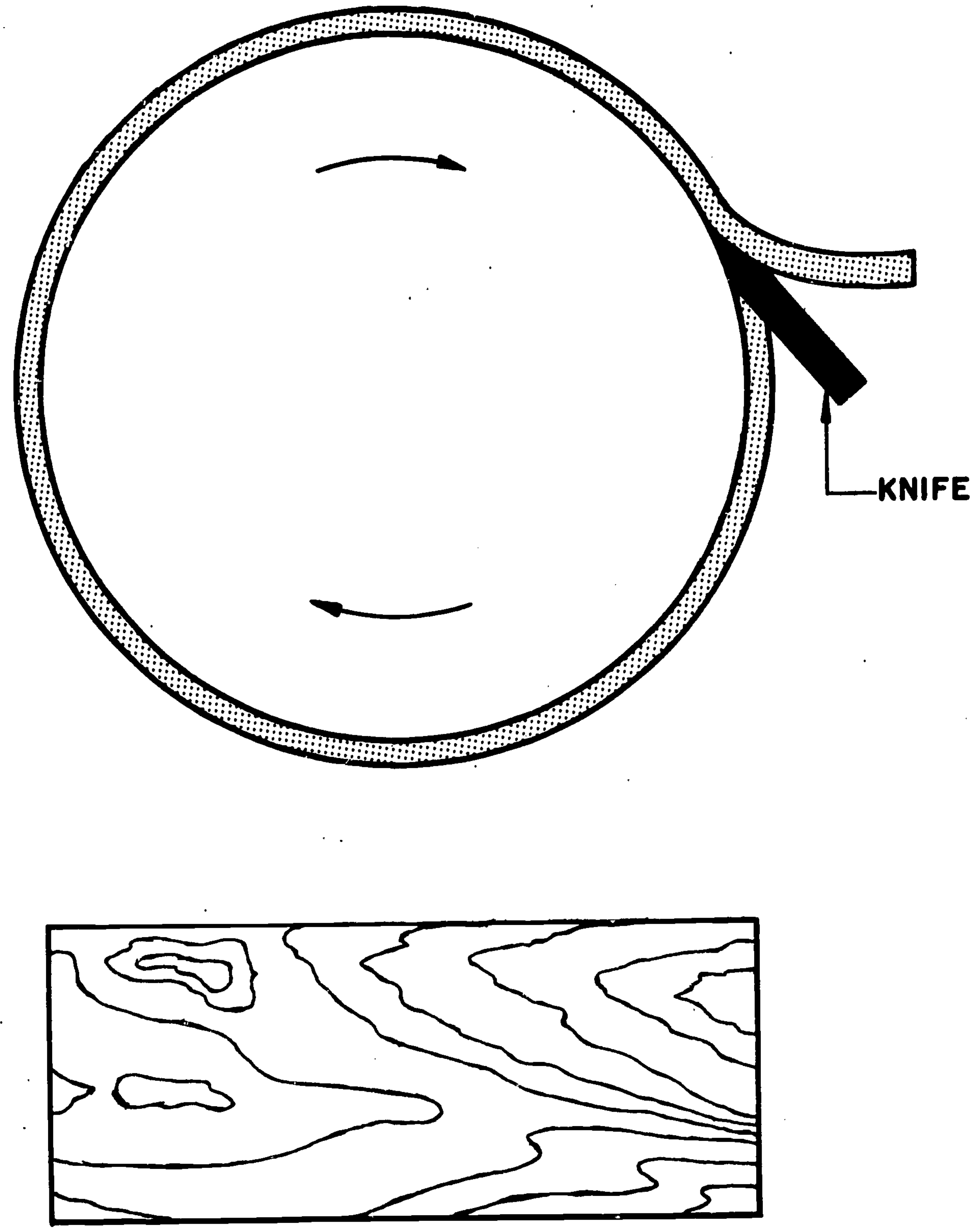
NORMALLY LIMITED TO OAK



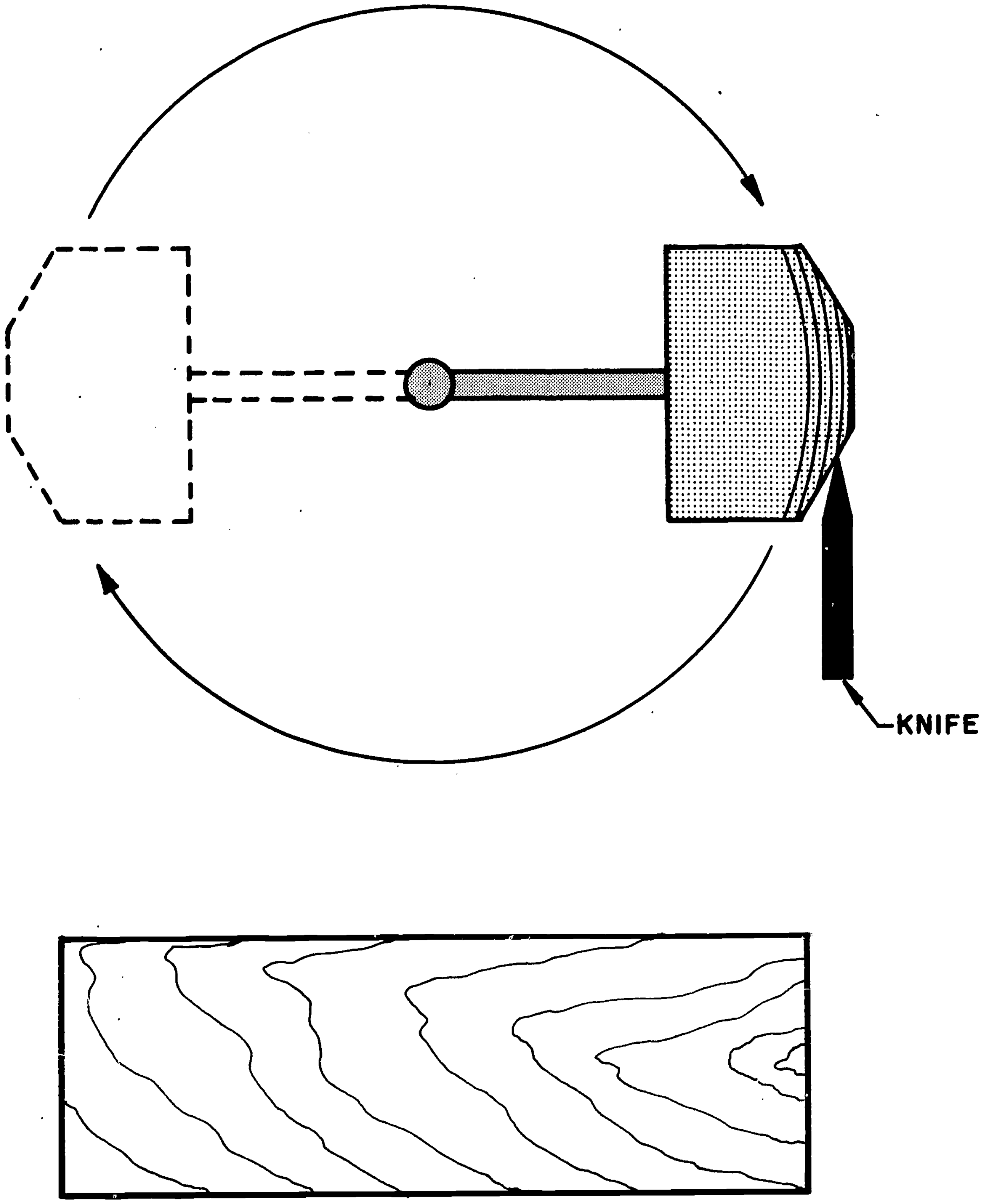
PLAIN SLICED VENEER



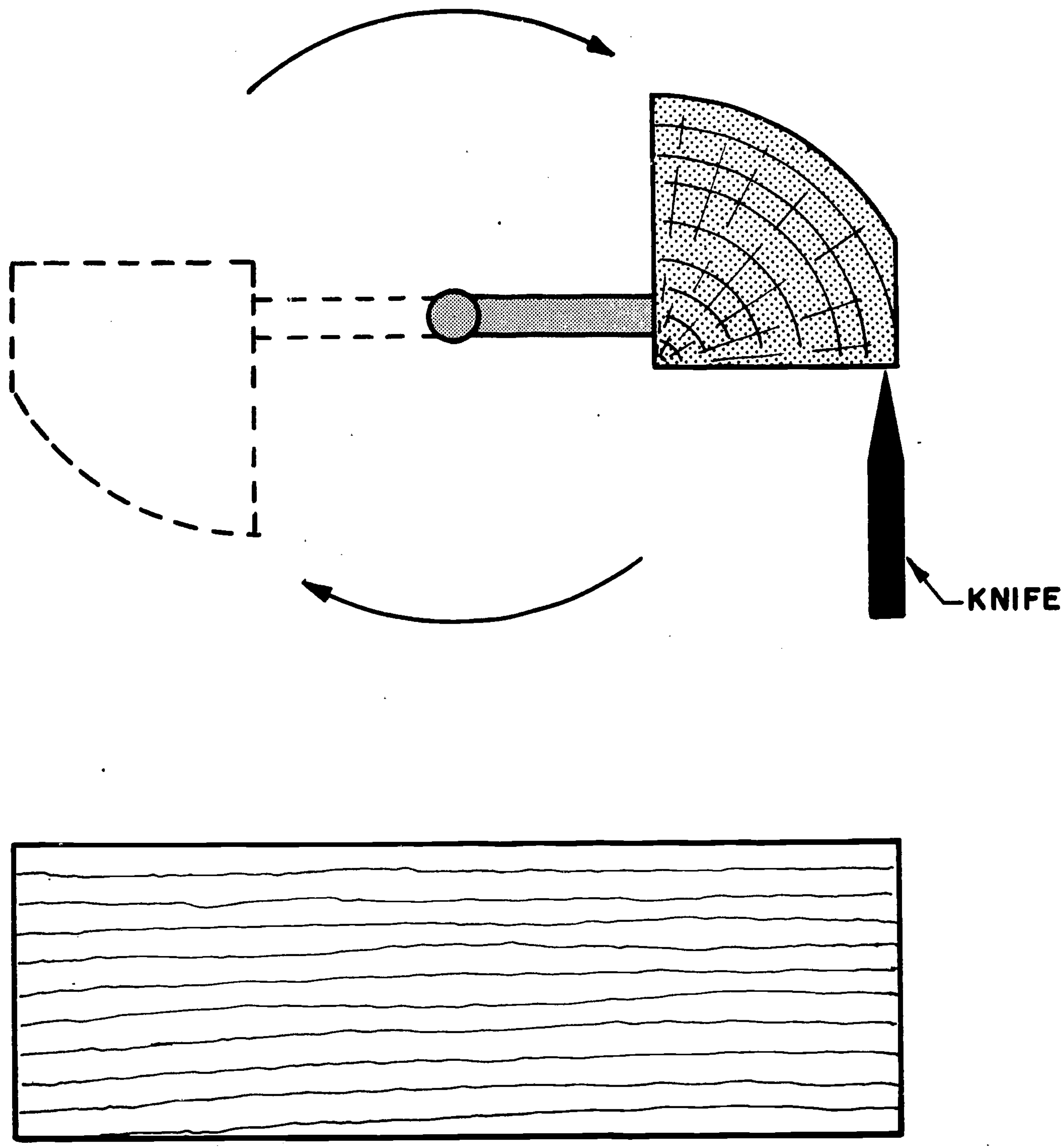
QUARTER SLICED VENEER



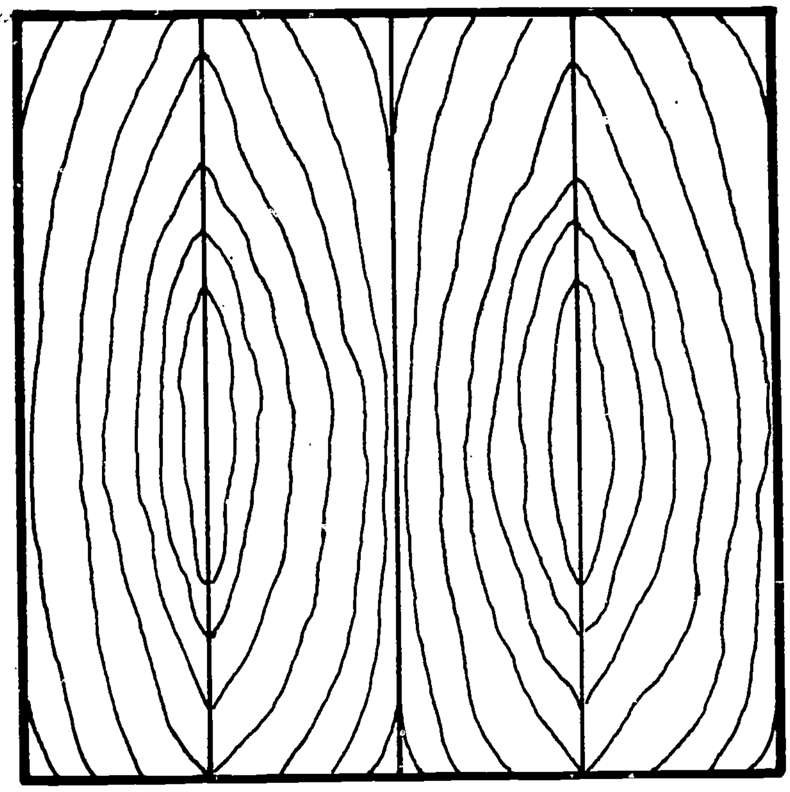
ROTARY CUT VENEER



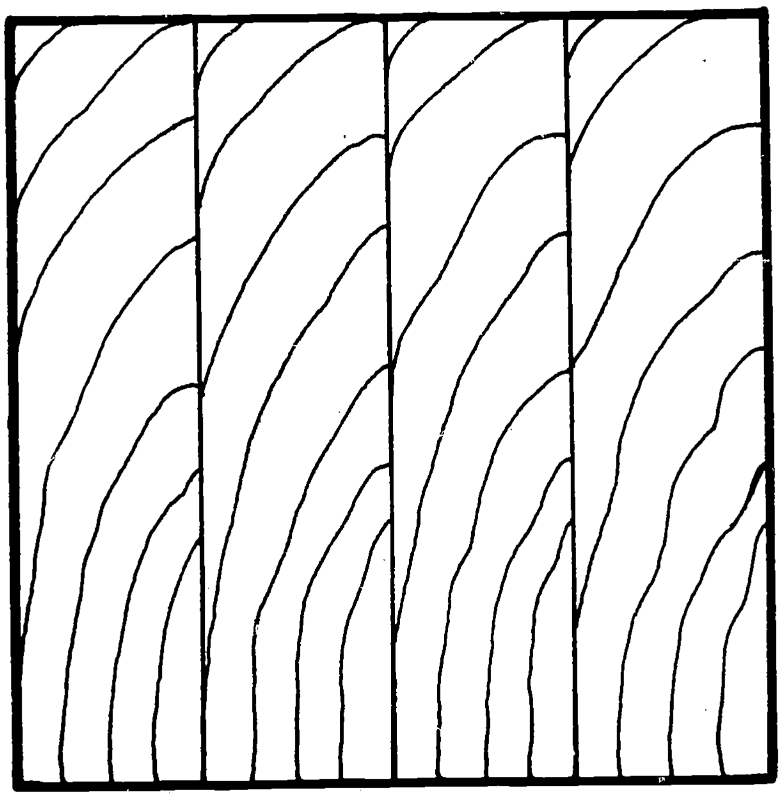
HALF-ROUND CUT VENEER



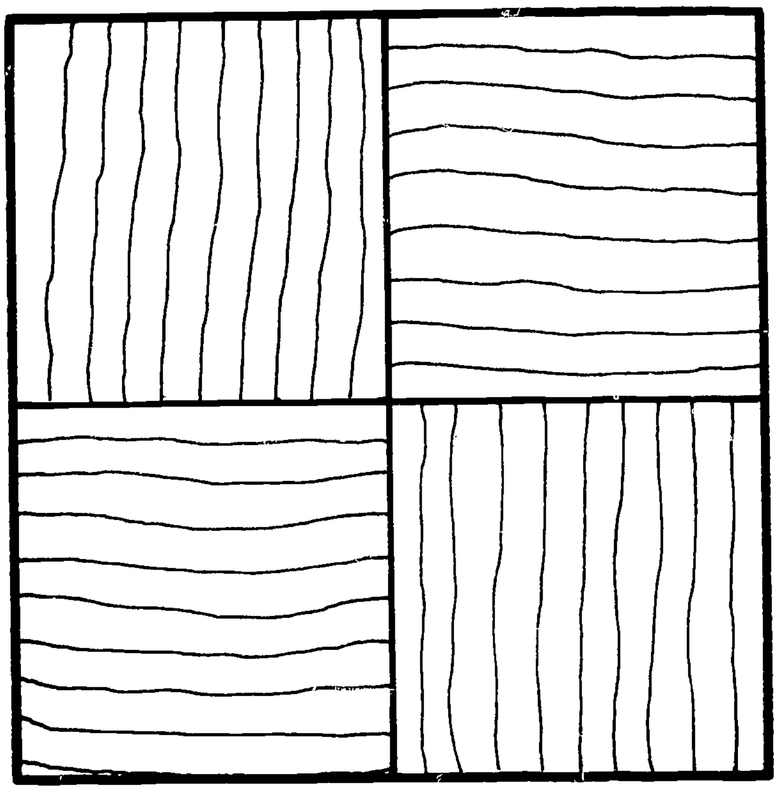
RIFT-CUT VENEER



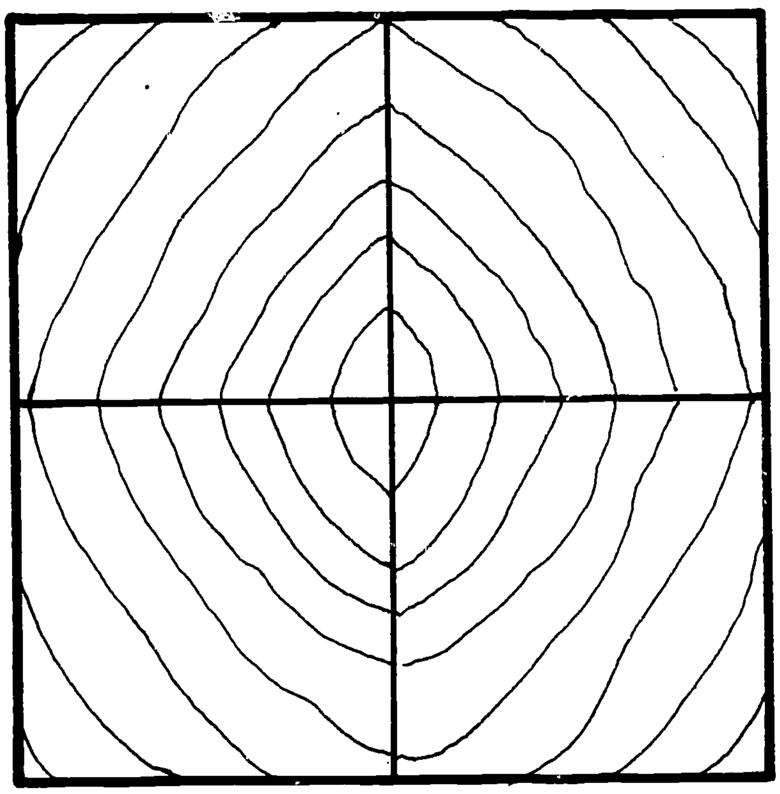
BOOK MATCHED VENEER



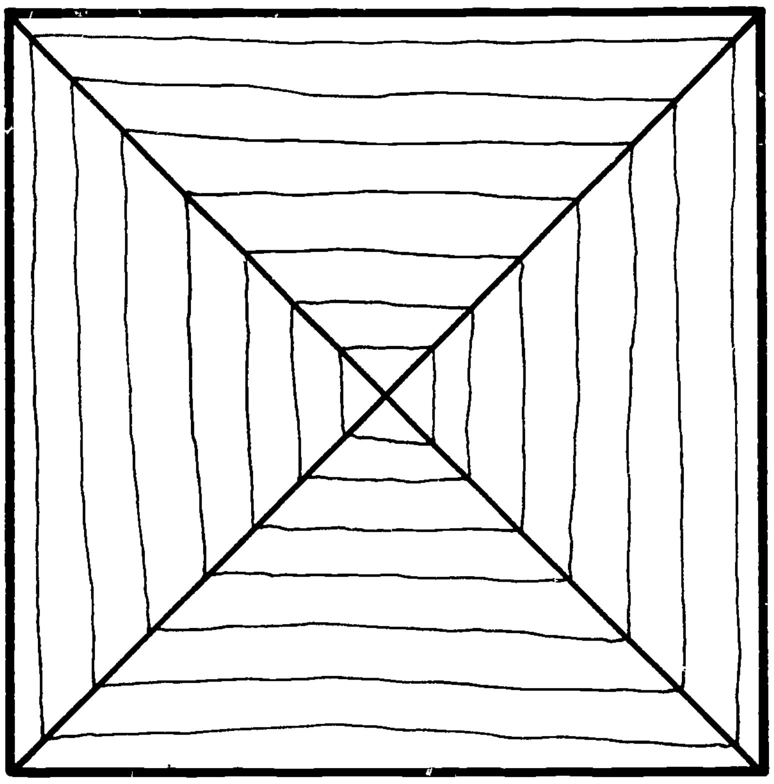
SLIP MATCHED VENEER



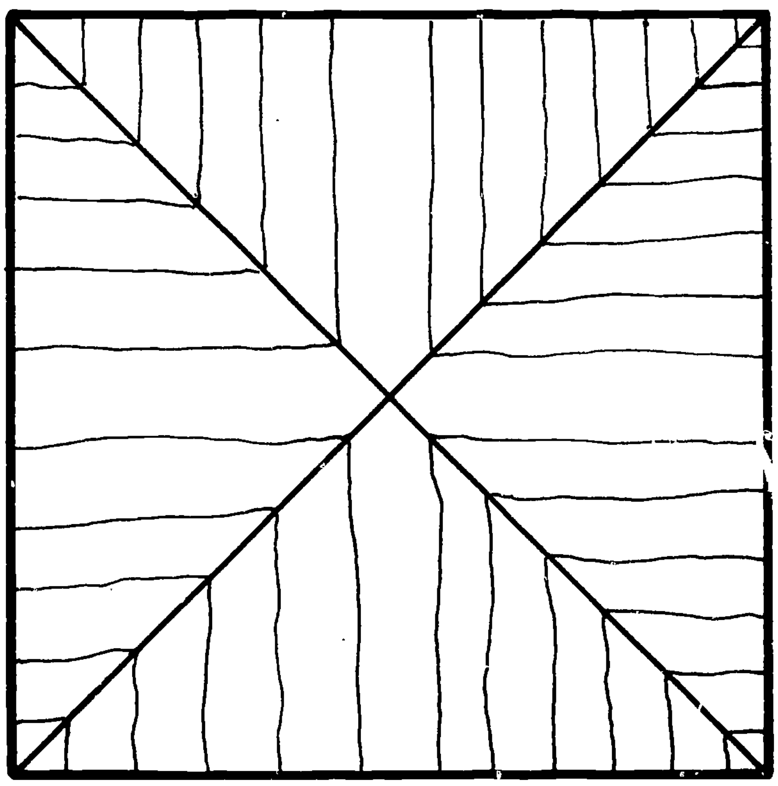
CHECKERBOARD MATCHING



DIAMOND MATCHING



BOX MATCHING



REVERSE BOX MATCHING

PLYWOOD

Edward Bernhard

The teaching aid is a three-dimensional wall chart pictorially depicting the production of plywood. It includes the various steps in the assembly of odd layers of wood from the basic log to the finished product.

A related lesson utilizing transparencies and an outline sheet to augment the wall chart will complete the formal lessons concerning plywood manufacturing. The students will then plan and work out a project using some of the principles learned regarding laminating veneers into a functional item.

Related Student Activities

1. Design and construct an original laminated project from wood veneers. This will include form construction, etc.

2. Construct a project by the lamination process using one of the forms available in the shop.

3. Construct samples of laminated wood and test relative strength. (3 ply, 5 ply, 7 ply, various cross bands and species of woods)

4. Choose one specific phase in the manufacture of plywood and write a related paper.

5. Write a paper on a specific use or a broad outline of many uses of the material.

Each student will have a choice of one paper and one working problem from the above list of class activities.

REFERENCES

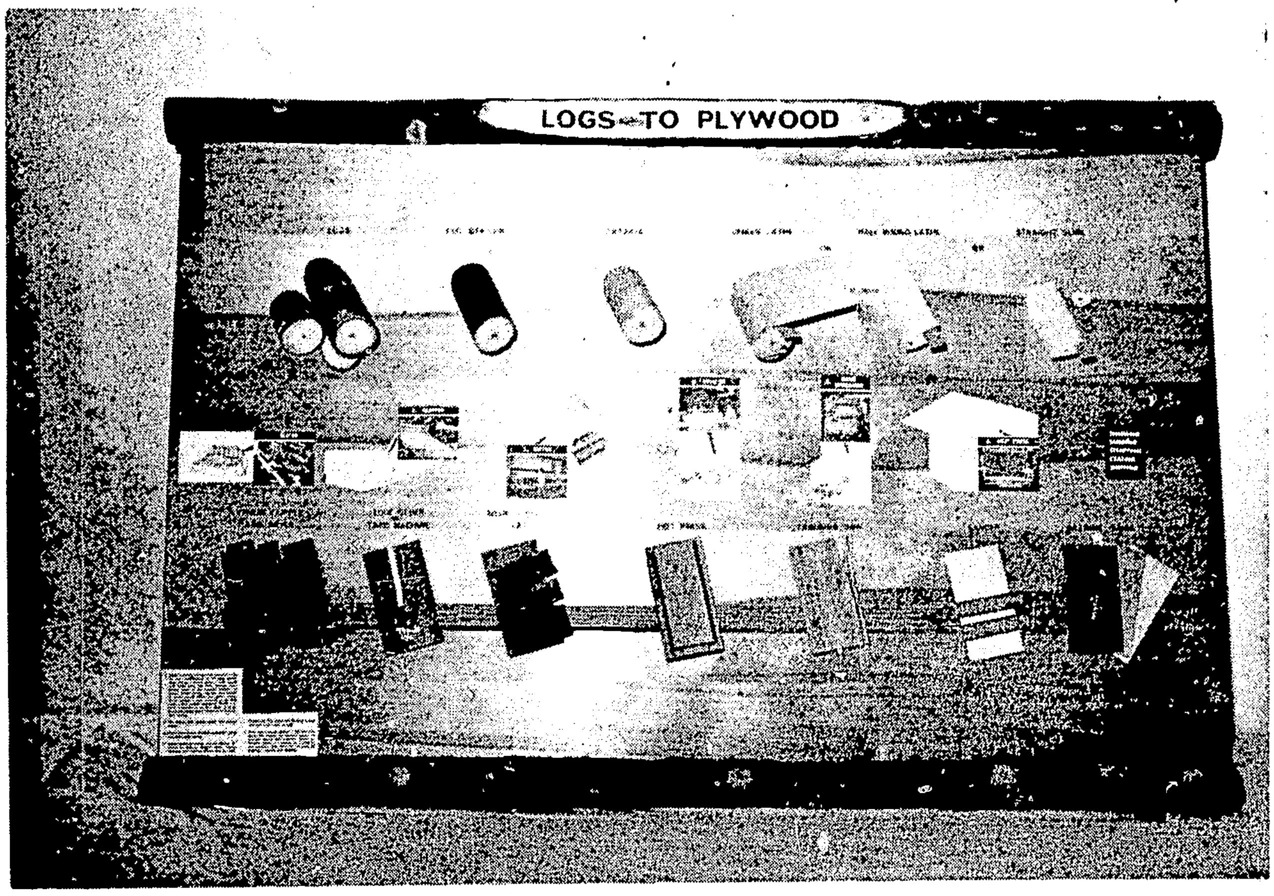
.... The Story of Hardwood Plywood. Arlington, Virginia: Hardwood Plywood Manufacturers Association.

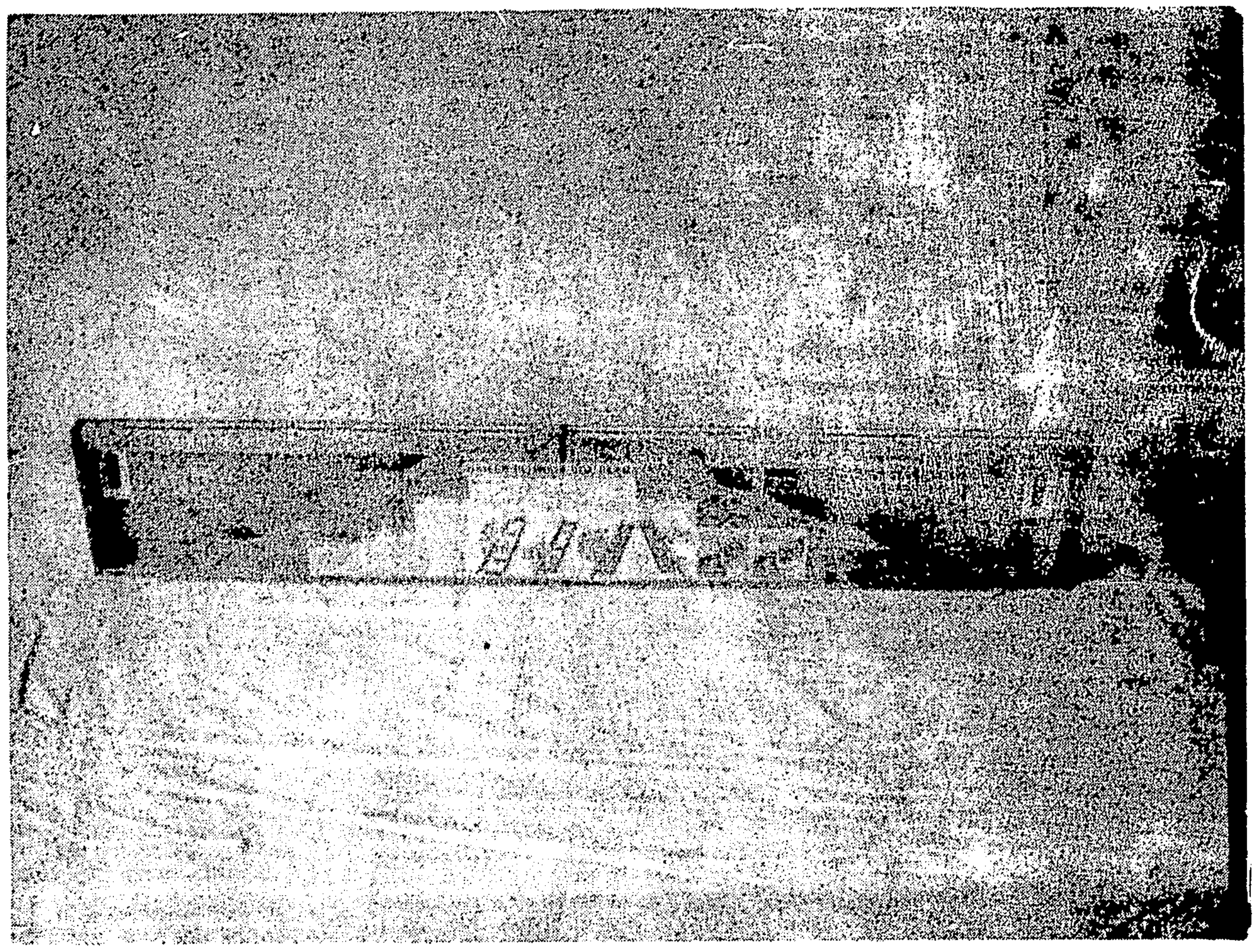
Feirer, John L. Woodworking for Industry. Peoria, Illinois: Chas. A. Bennett Co., Inc., 1963.

Gerbracht, Carl and Robinson, Frank E. America's Industry. Bloomington, Illinois: McKnight and McKnight Publishing Co., 1964.

Groneman, Chris H. and Glazener, Everett R. Technical Woodworking. New York: McGraw-Hill Book Company, 1966.

Wagner, Willis H. Modern Woodworking. Homewood, Illinois: The Goodheart-Willcox Co., 1967.


LOGS TO PLYWOOD

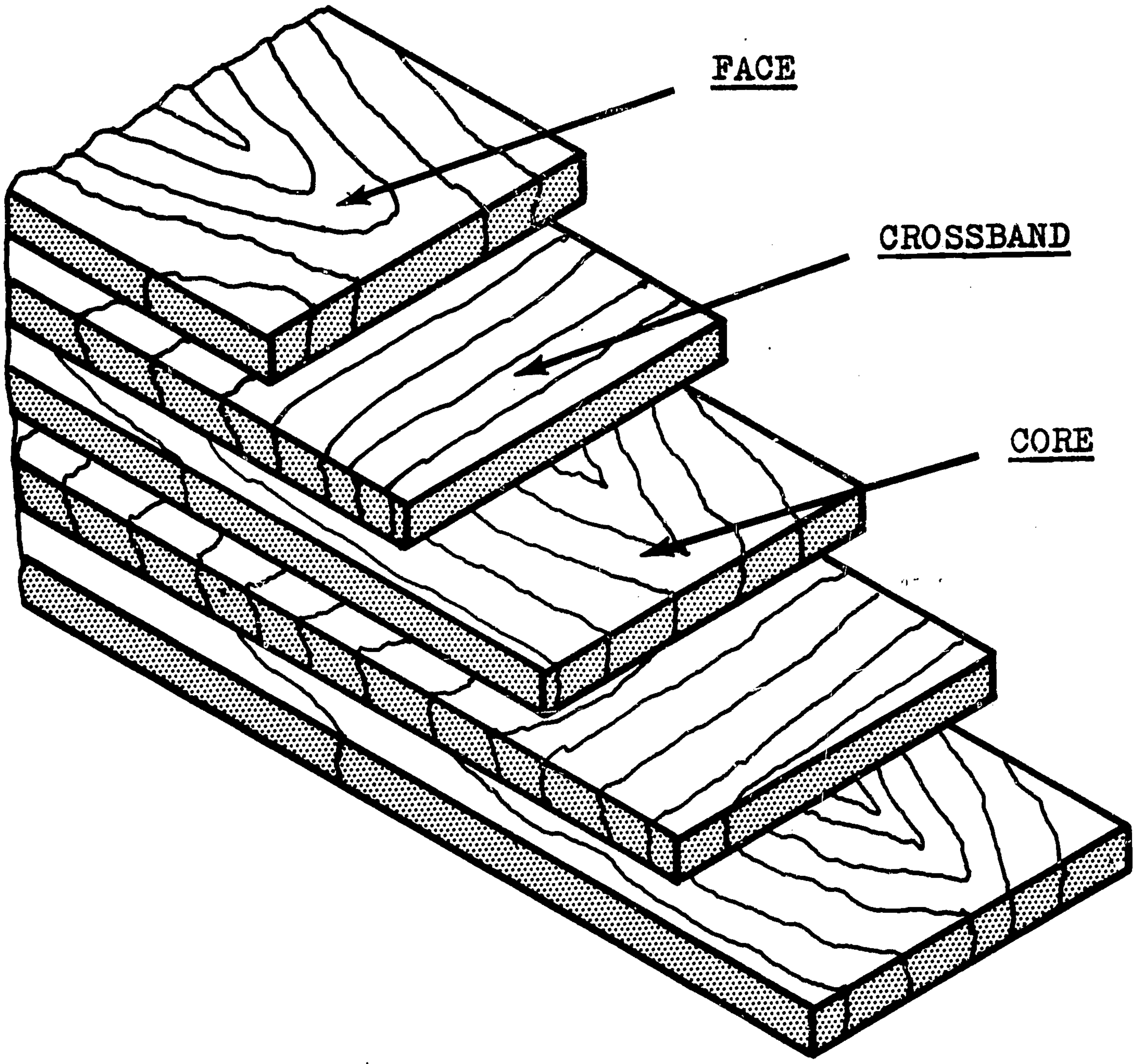


THE CORE CONSTRUCTION OF

HARDWOOD PLYWOOD

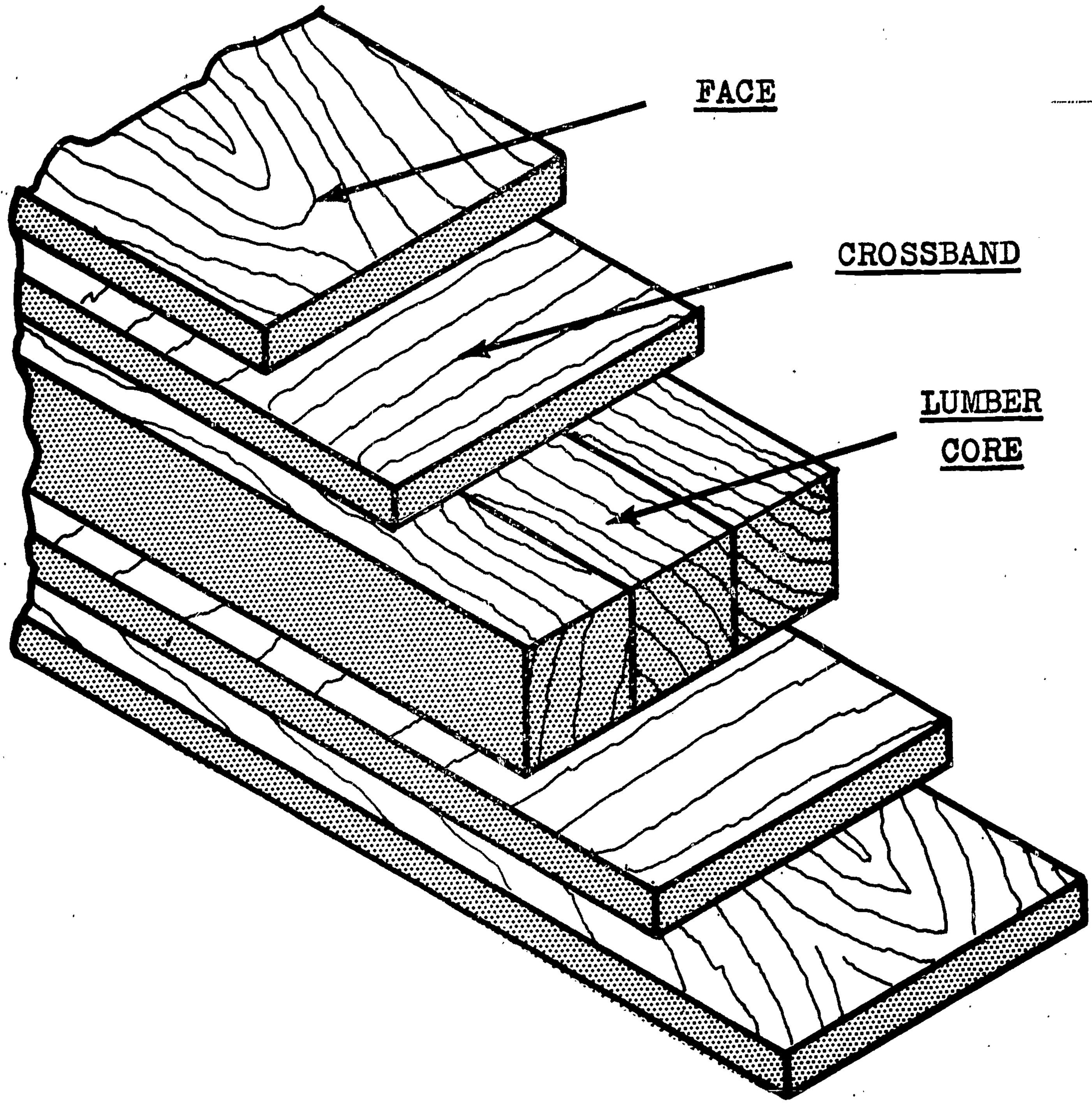
THIS VISUAL AID CAN BE USED TO INTRODUCE THE STUDENTS TO THE DIFFERENT TYPES OF CORE CONSTRUCTION, THE USE OF FACE LAYERS, AND WHY CROSSBANDING IS NECESSARY IN HARDWOOD PLYWOOD.

OTHER INFORMATION YOU CAN RELATE IN HARDWOOD PLYWOOD IS HOW IT IS MADE, THE STRENGTH AND STABILITY, AND ITS USES.



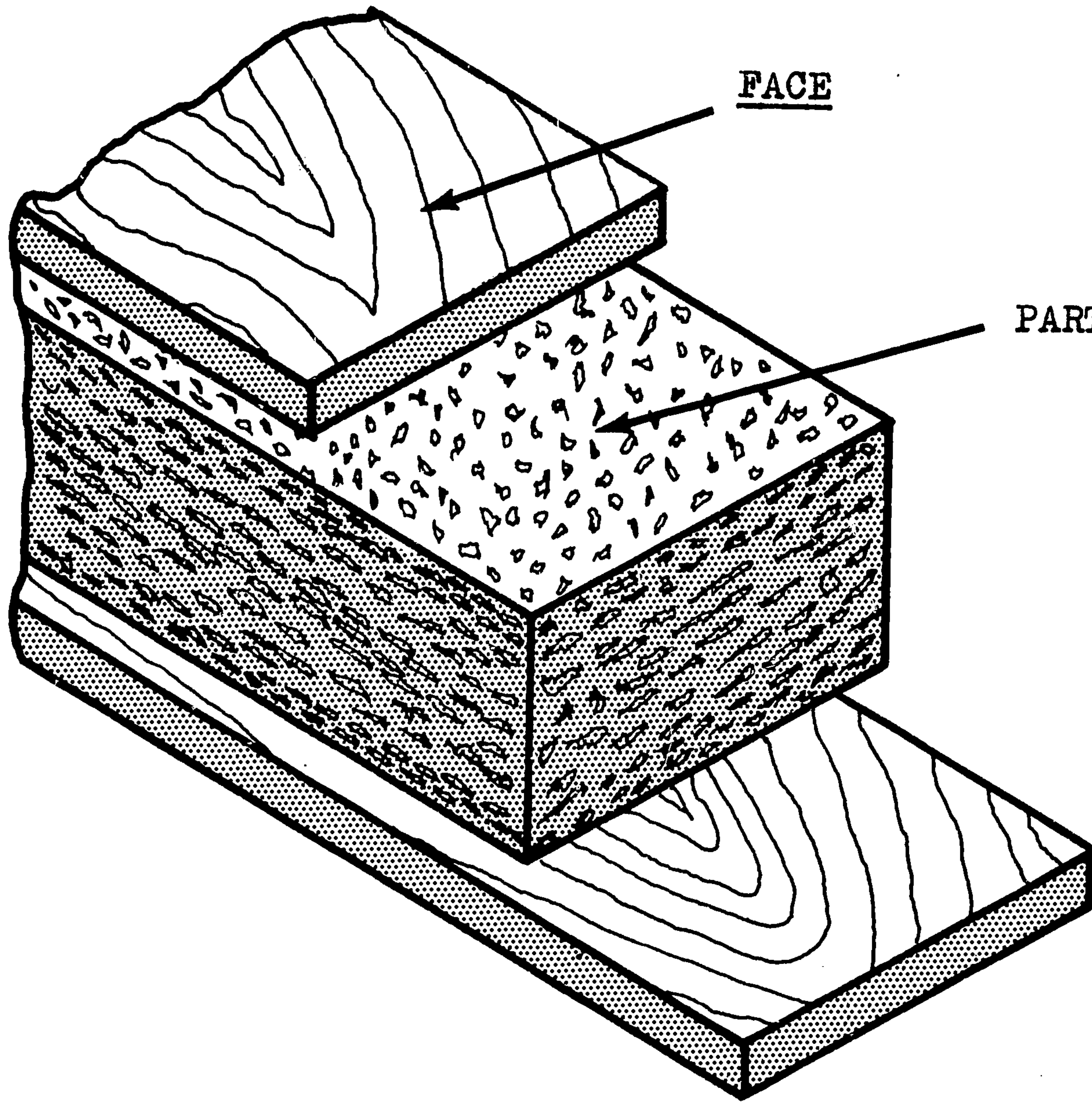
VENEER CORE CONSTRUCTION

MOST PLYWOOD IS OF ALL-VENEER CONSTRUCTION (VENEER CORE). THIS CONSTRUCTION IS SPECIALLY SUITED FOR EXTERIOR, CURVED, AND THIN PLYWOOD ($\frac{1}{4}$" AND THINNER). THE NUMBER OF PLIES REQUIRED DEPENDS ON HOW THE PANEL WILL BE USED, BUT GENERALLY, THE GREATER THE NUMBER OF PLIES, THE MORE STABLE THE PANEL WILL BE AND THE MORE UNIFORM ITS STRENGTH.



LUMBER CORE CONSTRUCTION

THE CENTER OR CORE PLY IS OF LUMBER STRIPS, ONE TO FOUR INCHES WIDE, EDGE GLUED TOGETHER SO AS TO EQUALIZE STRESSES. THIS CONSTRUCTION IS GENERALLY USED FOR FURNITURE, BUILT-INS, FIXTURES, AND WHEN EDGE TREATMENT OF WOOD IS DESIRED, OR WHERE BUTT HINGES ARE TO BE USED. LUMBER CORE PANELS WITH FACE WOOD BANDED ON ALL FOUR EDGES MAY BE SPECIALLY ORDERED.

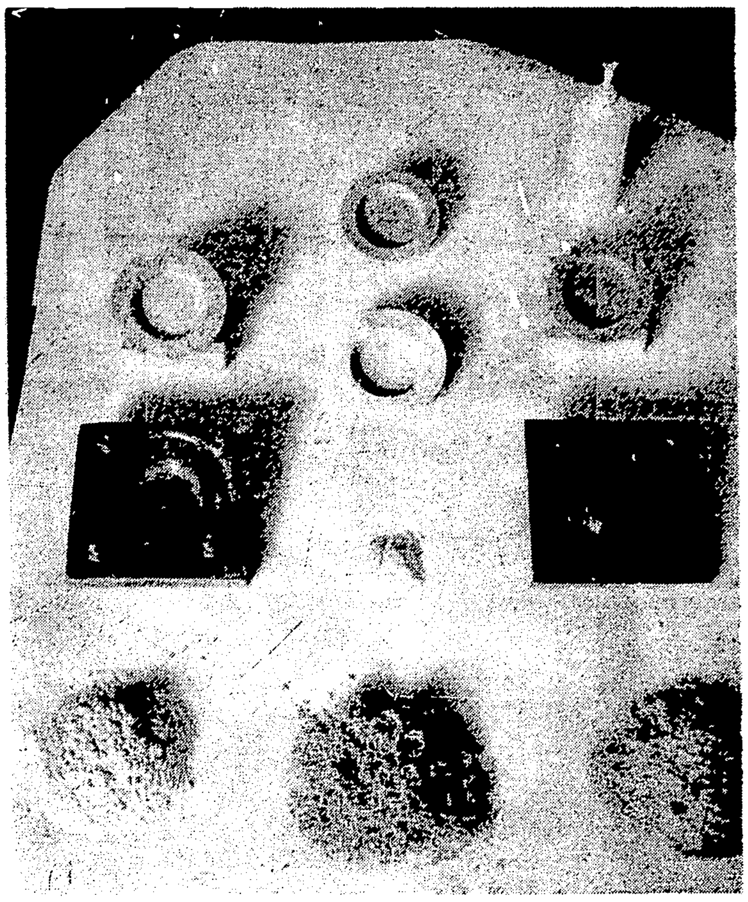


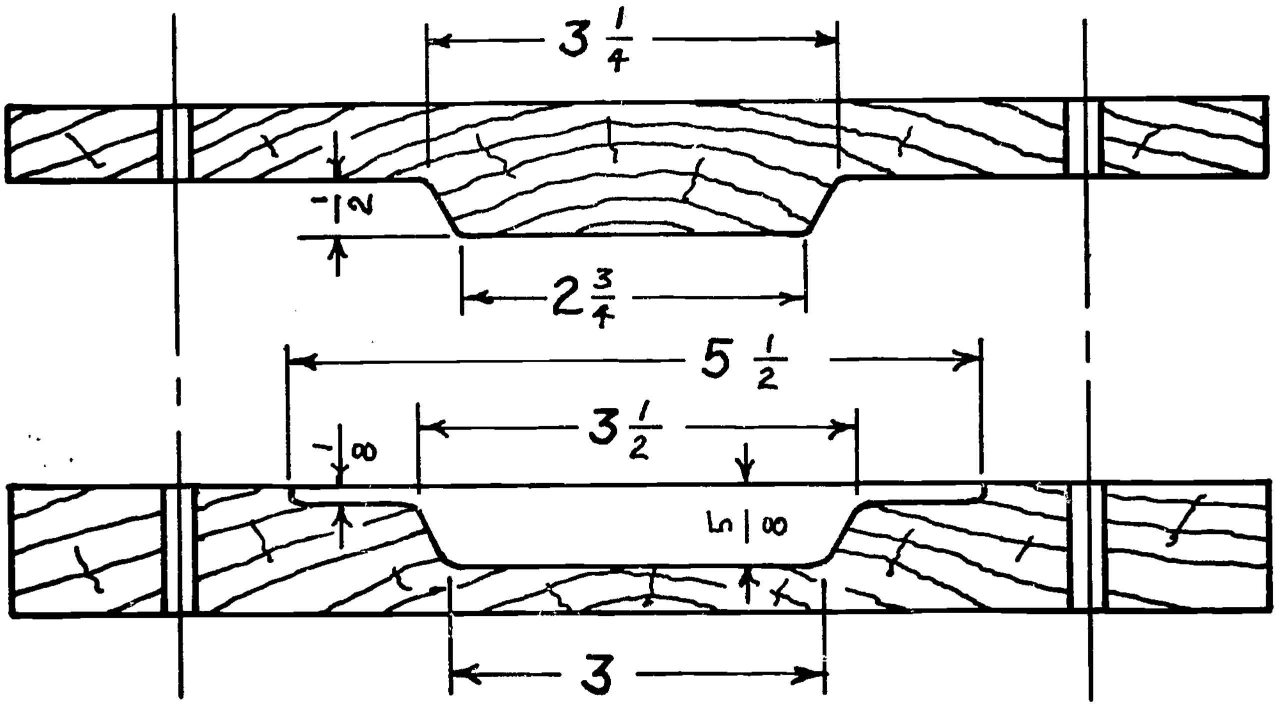
PARTICLEBOARD CORE CONSTRUCTION

THIS CONSTRUCTION IS MADE WITH A CORE OF MAT FORMED WOOD FLAKES AND CHIPS WITH RESIN BINDERS TO WHICH HARDWOOD VENEERS ARE BONDED TO PRODUCE 3 OR 5 PLY PANELS, $\frac{1}{4}$" THICK AND THICKER. PARTICLEBOARD CORE IS USED FOR CABINETRY, DESKS, SHELVING, AND TABLE TOPS. ITS SMOOTHNESS MAKES IT A GOOD GLUABLE SURFACE TO WHICH HARDWOOD VENEERS CAN BE ATTACHED; ITS STABILITY MAKES IT AN EXCELLENT CORE WHEN FLATNESS IS REQUIRED.

MOLDED ASH TRAYS

BY FRED SCHUMM





MOLDED ASH TRAYS

Fred Schumm

Molded wood products have been used for a long time by countless people. Usually, however, the individual is not aware that it is a wood product because the shape is such that one normally thinks that the item is made solely out of plastic and in most cases they are correct. Products in which molded wood can more commonly be found are: cafeteria carrying trays, salad bowls and dishes, automobile glove compartments, Church seats, and school desk seats.

The purpose of this outline is to describe the ease and economy of molding ash trays with wood particles. Junior high schools, senior highs and colleges can find challenge and easy success in molding wood particles. The items that can be made are limitless!

Materials and Equipment

Source for sawdust - circular saw
Source for wood flour - belt sander's dust bag
Hardwood mold 2" x 7" x 7" - see diagram on previous page
Small plastic bag
Water atomizer
Grain balance
Hydraulic press with guage or equivalent
High frequency welder or 170° F. oven
Parting compound - such as wax
Refrigeration (not really necessary)

Procedure

1. Select clean material

   a. Sawdust can be divided into three groups

      1) long slender particles
      2) very fine small particles
      3) the combination of the two

   b. Sanding dust can also be used.
      The selection of which material to use depends on the smoothness and density of the finish desired.

2. Secure 35 grams of wood particles by weight. Thirty five grams is roughly a tuna fish can leveled with loose and unpacked wood particles.

3. Secure 20 grams of urea formaldehyde adhesive by weight. Weldwood's Plastic Resin was the urea formaldehyde used.

4. Take the small plastic bag and pour in the wood particles, the urea formaldehyde powder and mix them well by shaking the bag vigorously.

5. To adequately prepare the mold for proper release many steps can be taken, select anyone that works. Regular past wax was successfully used along with Saran Wrap or any cellulose paper. The cellulose adheres to the particles forming a smooth easy to finish surface. Vinyl sheets could be used as a complete finish.

6. Sprinkle a uniform ¼ inch layer of particles onto the mold. Then spray a fine uniform mist over this particle-adhesive layer. One quick shot is enough! Repeat this process until the entire supply of particles are depleted.

7. Remove excess particles as the mold is put together also fastening the screws and nuts.

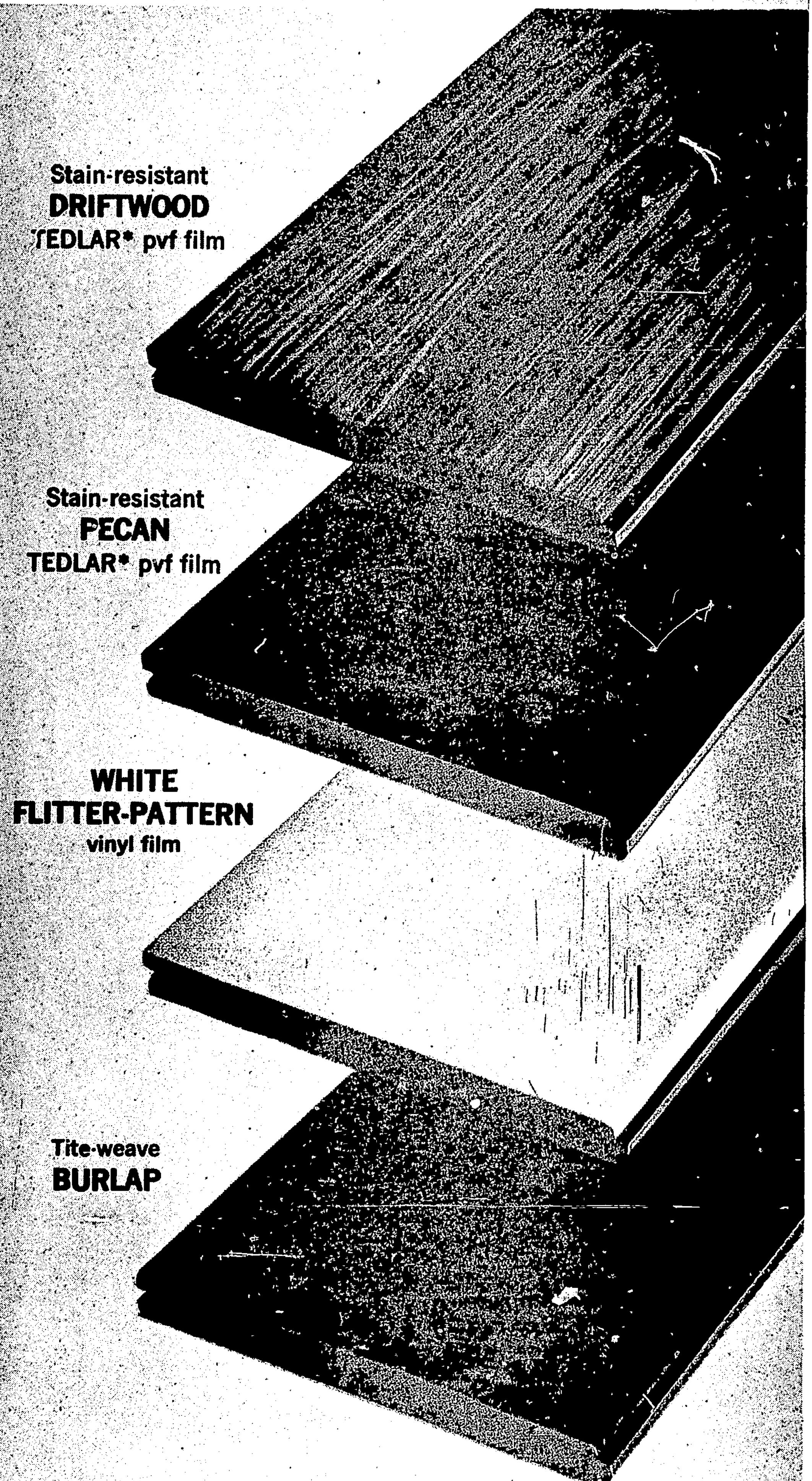
8. Use the hydraulic press or equivalent to attain approximately 6000 pounds per square inch pressure. Then screw the mold together tightly.

9. To cure the adhesive heat must be applied. The high frequency welder does a fine quick job, however any heat source of 170° F. will work.

10. The last step is to cool the mold either by refrigeration or time. Then remove the ash tray. No further work should be necessary except perhaps trimming and finishing it if a fireproof or decorative finish is desired.

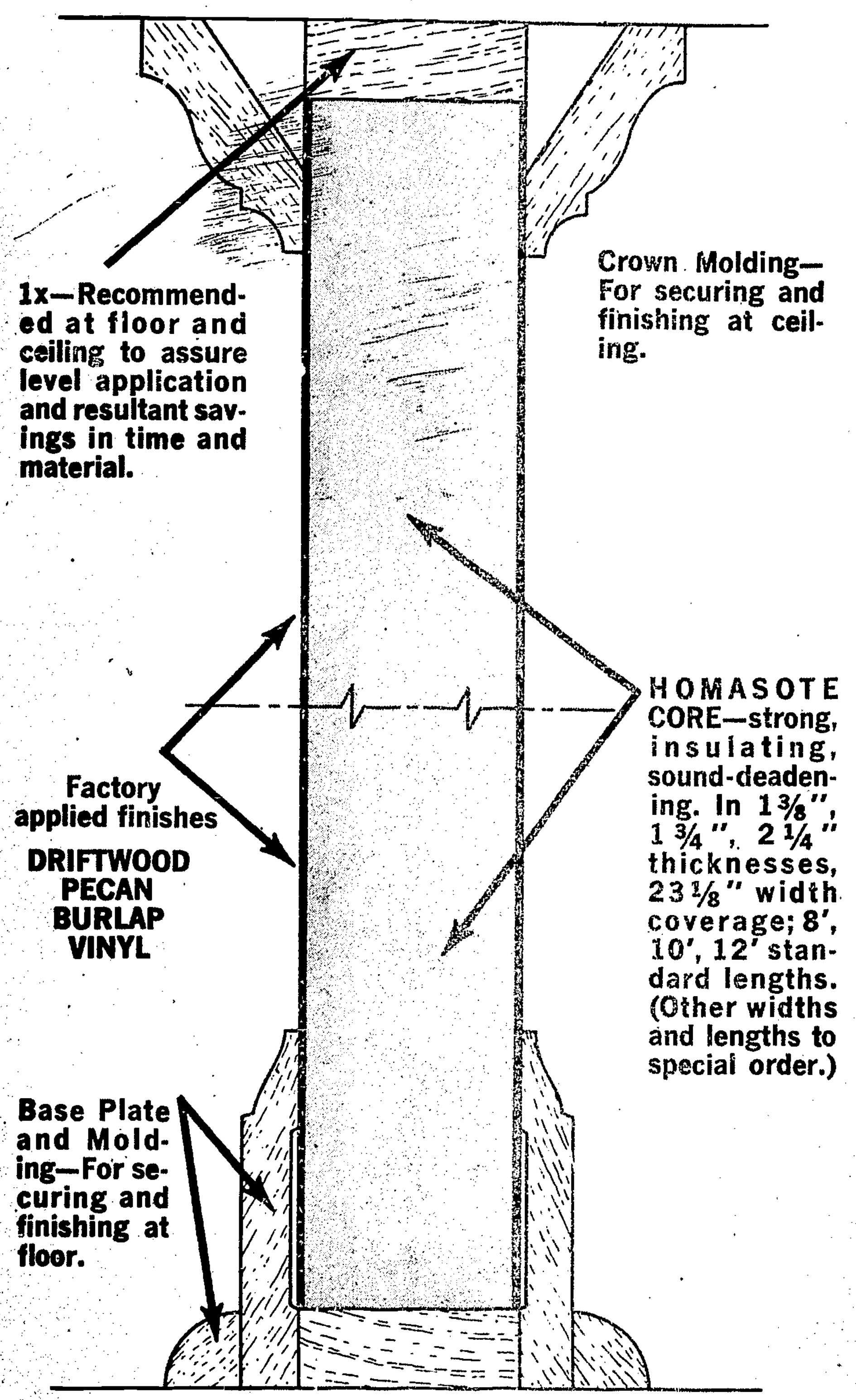
It might be interesting to add that the expense was calculated at 2¢ for the adhesive for each ash tray. The sawdust was free and plentiful. Total time using the high frequency welder and refrigeration was 20 minutes with one man running the operation.

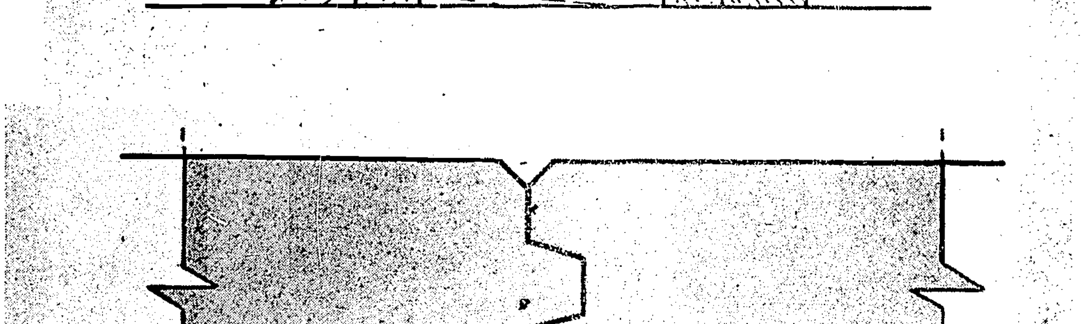
with practical, decorative, factory-applied finishes



A perfect blending of practicality and beauty is achieved through the choice of factory-applied finishes available with Homasote Interlock Wall Panels. Normal application costs are slashed and a striking appearance is retained with an absolute minimum of maintenance.

TYPICAL APPLICATION AND CONSTRUCTION DETAIL



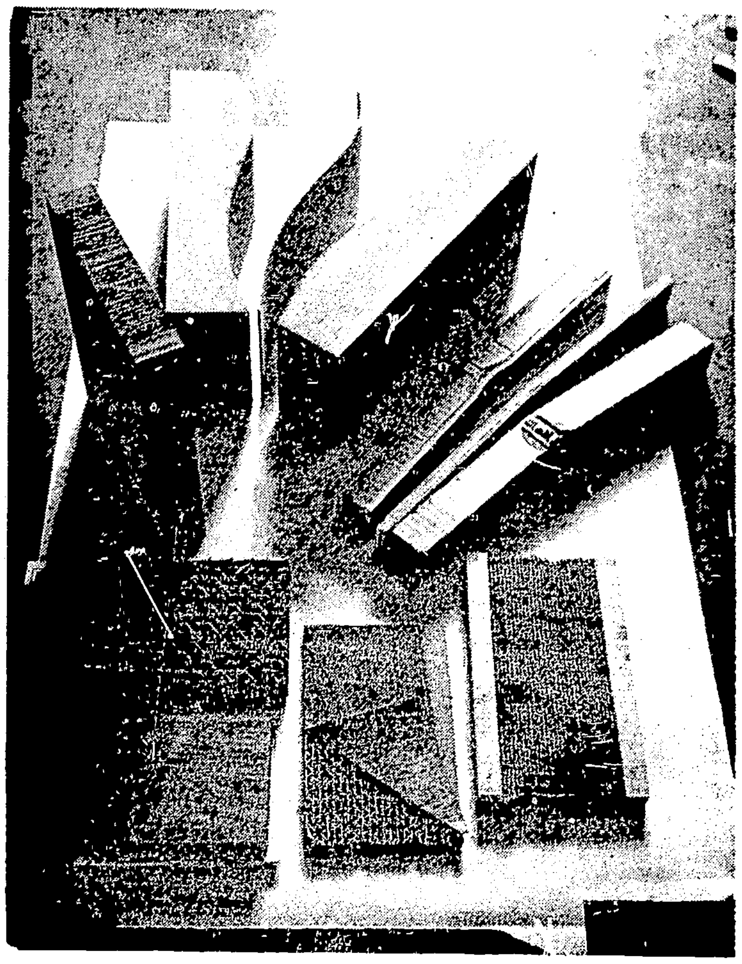


Matched tongue-and-groove interlock, with v-joint on both faces—simplifies application; assures tight precision fit; makes panels completely reversible.

Honeycomb Laminating
Sandwich Construction

by

Chester B. Ingraham



PURPOSE: In order to teach one of the new techniques used in wood fabrication, that of using the honeycomb paper cell, the following approach was used to employ the materials on hand and those easily obtained to produce a similar product.

There are companies which provide paper impregnated honeycomb material in a variety of thicknesses, cell size openings, widths and lengths. This material is sold only in large lots, so the possibility of purchasing it is poor. For this reason it was decided to use corrugated cardboard boxes glued face to face until the desired thickness was acquired.

USES: Many applications can be made with honeycomb cardboard material such as:

1. Honeycomb cored veneered doors.

2. Laminated honeycomb curved chair seats and backs.

3. Curved forms for wood laminating veneers.

4. Packing material for delicate tool storage.

Principle: The forces acting on any beam, such as a table top, create pressure greatest on the top and bottom surfaces or skin, and less pressure at its center. Therefore, honeycomb laminated parts will possess strength suitable for many wood applications where solid materials are now employed, giving strength which is just as suitable as solid material and with much less weight involved.

EXPERIMENTS:

A. Laminated beams were constructed one inch wide and one-and-one-quarter inches deep using the following materials over honeycomb corrugated cardboard cores:

   1. One quarter inch plywood was glued to the top and the bottom of the honeycomb core. This beam required 500 pounds of pressure to break the beam.

   2. One quarter by one inch plywood was glued to another piece of the same size without the honeycomb core. This beam required less than 50 pounds of pressure to break it.

   3. A beam one inch by one-and-a-half deep with 1/24 inc veneer glued on the top and bottom was tested and required 100 pounds pressure to break it.

These simple experiments help to illustrate the added stren gained by increasing the depth of a beam using light weight material as a core.

CONSTRUCTION TECHNIQUES:

A. Several methods can be employed to cut the cardboard to the desired width. Some of these are:

   1. Cutting strips with a pocket knife.

   2. Cutting strips with the table saw.

   3. Cutting strips with the band saw.

4. A simple way to cut strips to width is by setting the guage of a sheet metal squaring sheer to the desired width and shearing strips with this machine.

B. The time required to glue several layers of cardboard can be decreased by employing a wood welder to set the glue faster. A layer one inch thick or thicker can be welded at one time with a high frequency wood welder. No clamps are needed because the pressure applied by hand under the wood welder is enough to bond the layers together.

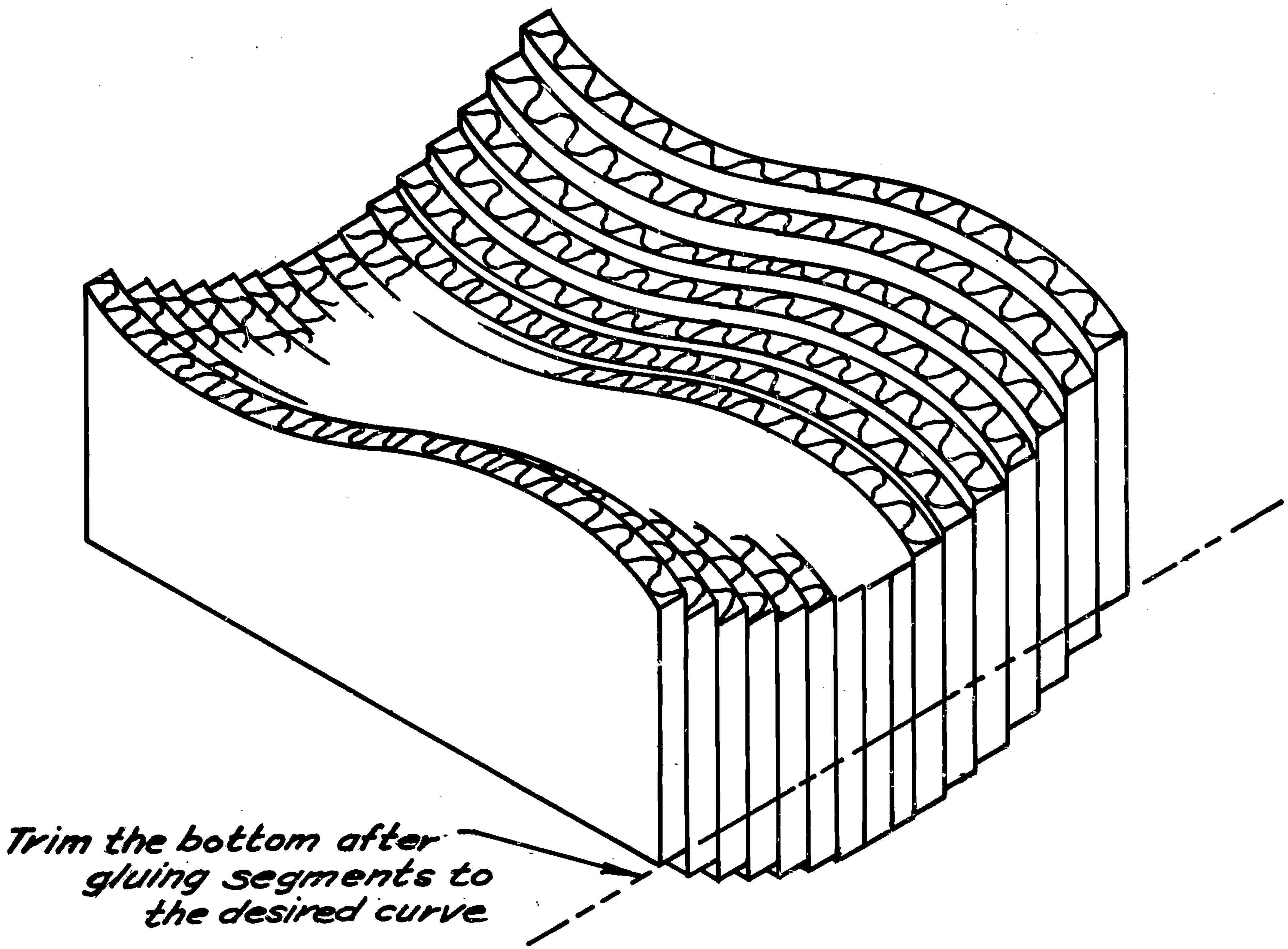
C. After the buildup to the desired thickness has been accomplished, two strips of wood are glued on each side to add stiffness during the jointing and surfacing operations.

FORMING LAMINATED CURVES USING THE HONEYCOMB STRUCTURE AS A FORM:

A. Corrugated cardboard honeycomb material shaped to a desired curve can be used to make curved laminated shapes.

B. Compound curves may be shaped by cutting the desired curve through a stack of cardboard anchored at each end, by bolting or by drilling a hole through the layer of cardboard, any method to keep the segments keyed together. Then these layers are curved along the opposite axis so that a compound curve results in two directions.

COMPOUND LAMINATING FORM



PAPER MAKING

by

Thomas G. Latimer

PURPOSES

A. To illustrate visually the various processes involved in paper making.

B. To show the practical use and versatility of a flannel board.

PROCESSES

A. DIGESTER. In the digester, sometimes known as the "pressure cooker," wood chips are cooked with chemicals under steam pressure and reduced to tiny fibers.

B. WASHER. These fibers go through a washing process in which the pulp is sprayed as it revolves on large drums.

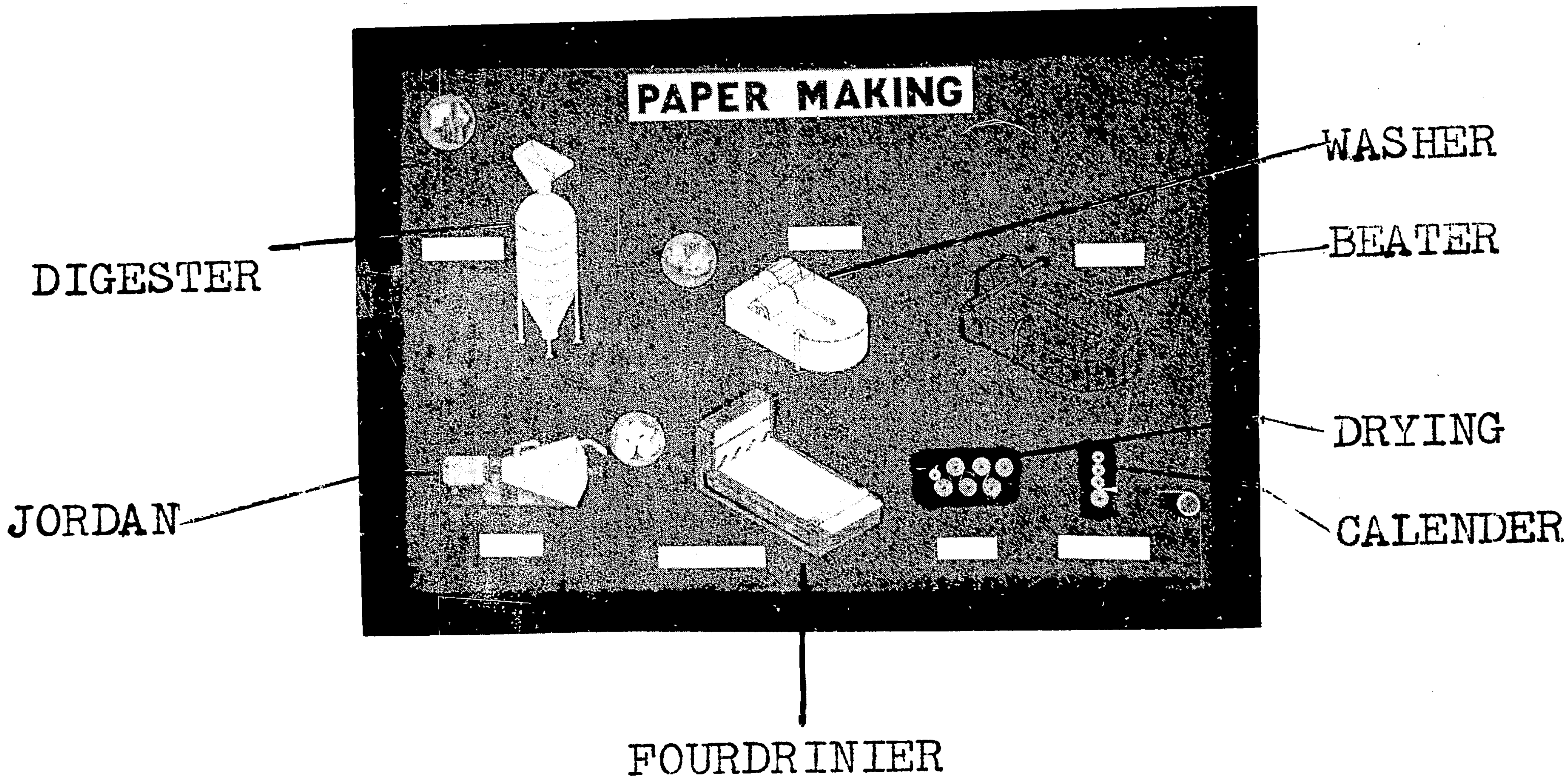
C. BEATER. Moving into the beater, the fibers are separated from bonding; also sizing and coloring are accomplished in this stage.

D. JORDAN. Next the pulp passes through the Jordan, where fibers are rubbed and cut to required degree.

E. FOURDRINIER. After more water is added, the pulp moves onto the Fourdrinier, the wire screen part of the paper making machine where the wet sheet is formed from the pulp.

F. DRYING. In the drying process, the sheet moves at speeds up to 2600 feet per minute.

G. CALENDER. Finally, the dried paper passes through calenders to give it required smoothness before it is placed on rolls.


PAPER MAKING
WASHER
BEATER
DIGESTER
DRYING
JORDAN
CALENDER
FOURDRINIER